Marine Engineering

JANUARY, 1906

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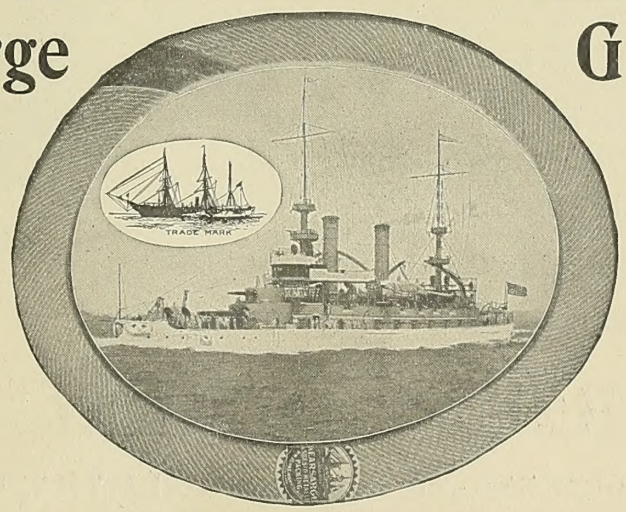

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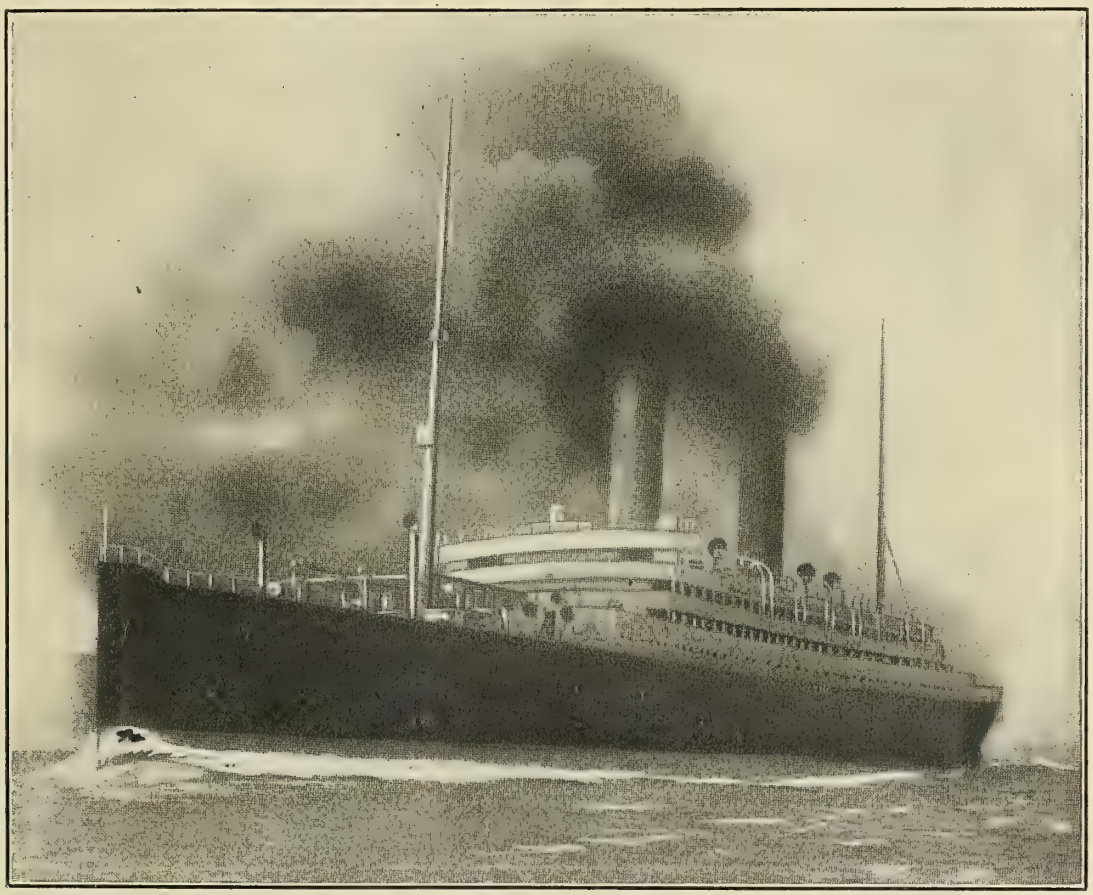
Marine Engineering

JANUARY, 1906.

THE NEW TURBINE LINER CARMANIA.

Built by John Brown & Co., Limited, at their Clydebank yard, for the Cunard Steamship Company, the *Carmania* is remarkable as being the largest turbine steamer as yet constructed. She is further remarkable as being the first turbine vessel built for traffic between the United Kingdom and the United States. In building the *Caronia* and the *Carmania* the Cunard Company has provided two large and fine ships, which, even with ordinary machinery, would have been notable. But in fitting the *Carmania* fitted with quadruple expansion engines driving twin screws, while the *Carmania* has triple screws driven by three separate Parsons turbines. The only difference in the form of the hull is that rendered necessary by the three shafts. The center shaft is driven by a high-pressure turbine, and each of the side shafts by a low-pressure turbine, with the astern turbine at the after end, inside the low-pressure casing. The three propellers operated by these turbines are clearly shown in the illustration, an



THE CARMANIA ON TRIAL TRIP.

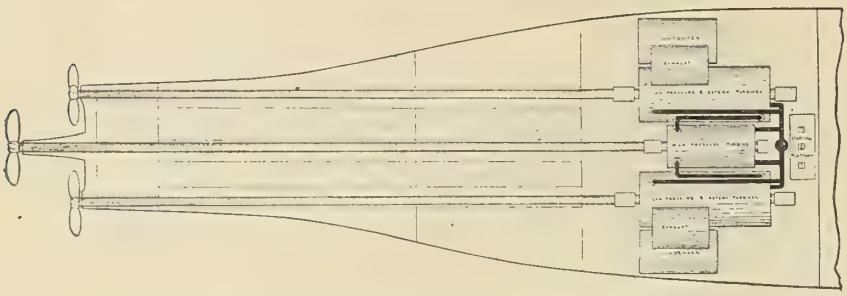
(Photograph, Journal of Commerce, Liverpool.)

with steam turbines, with the vessels identical in every other respect, opportunity will be afforded to remove all doubt as to the value of turbines as compared with reciprocating engines. They are both now running on the Atlantic, long before the two swift leviathans are ready, and from them much will be learned as to the prospects of the express steamers now building.

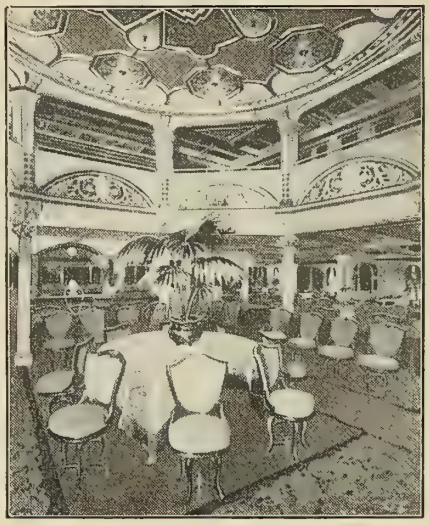
Except in the machinery, the *Carmania* is a sister ship to the *Caronia*, which has been already described.* The *Caronia* is important feature being that there is no outboard shaft, so that the engineer can at all times inspect the bearings, while the bossing out of the ship adds enormously to the strength. The rudder, it will be seen, is of the balanced type, the weight being 25 tons, while the bossing out of the stern above it, for the reception of the steering gear, is clearly indicated. The vessel as she stood in the ways represented a launching weight of 13,500 tons.

The keel of the *Carmania* was laid on May 17, 1904, so that only 9 months were required to bring her to the launching stage

*Marine Engineering, April, 1905, page 164.



PLAN OF THE ARRANGEMENT OF TURBINES AND SHAFTING.



THE DINING SALOON.

(February 21, 1905), and the fact that there was worked into the structure an average of 1,420 tons of steel per month indicates the splendid resources of the Clydebank establishment.

The boiler pressure in the *Carmania* is 195 pounds, in place of the 210 pounds in the *Caronia,* and the turbines take steam at an initial pressure of 165 pounds, as compared with 200 pounds in the machinery of the earlier ship. Owing to the high vacuum desirable in the turbine machinery in order to insure the fullest economy the condensing surface, which is 27,030 square feet in the *Caronia,* is increased in the *Carmania* by 20 percent, while the capacity of the centrifugal pumps is increased by about 50 percent, so that the amount of circulating water they will be capable of discharging will be from 50 to 60 times the weight of feed water, as compared with a ratio of 25 to 30 times in the *Caronia.*

The area occupied by the *Carmania's* machinery is about the same as that required for the engines of the *Caronia,* but there is a saving in weight of about 5 percent. The turbines were assembled by Messrs. John Brown & Company at Clydebank, the drums, shafting and steel castings having been manufactured at their Sheffield works, and are the largest of the kind in existence. They have 1,115,000 copper blades, each fitted separately. What most impresses one when inspecting the engine room is the enormous size of the turbine casings; these turbines, on account of having to run at such relatively low revolutions, 185 per minute, being actually four times the size of anything yet constructed; the low-pressure turbine casings are 14 feet outside diameter and 36 feet long, and to give some idea of the size of such cylinders, the low-pressure cylinders of the largest Atlantic liners at present running are 9 feet 4 inches in diameter by 6 feet stroke. The main shafts measure 14½ inches in diameter.

The main condensers are cylindrical, and the circulating water is supplied by two powerful centrifugal pumps, each of the pumps having two engines in connection therewith. Every detail in the steam plant is of a type to insure a high economy, as well as reliability in working.

The boiler installation includes eight double-ended and five single ended boilers, working in all cases at a pressure of 195 pounds per square inch. These are arranged in two separate boiler rooms, and the exhaust gases pass through two elliptical funnels, which rise to a height of 135 feet above the level of the furnace. The boilers are fitted with Howden's heated forced draught, supplied by two large fans, each driven by two engines.

THE MUSIC AND DRAWING ROOM.

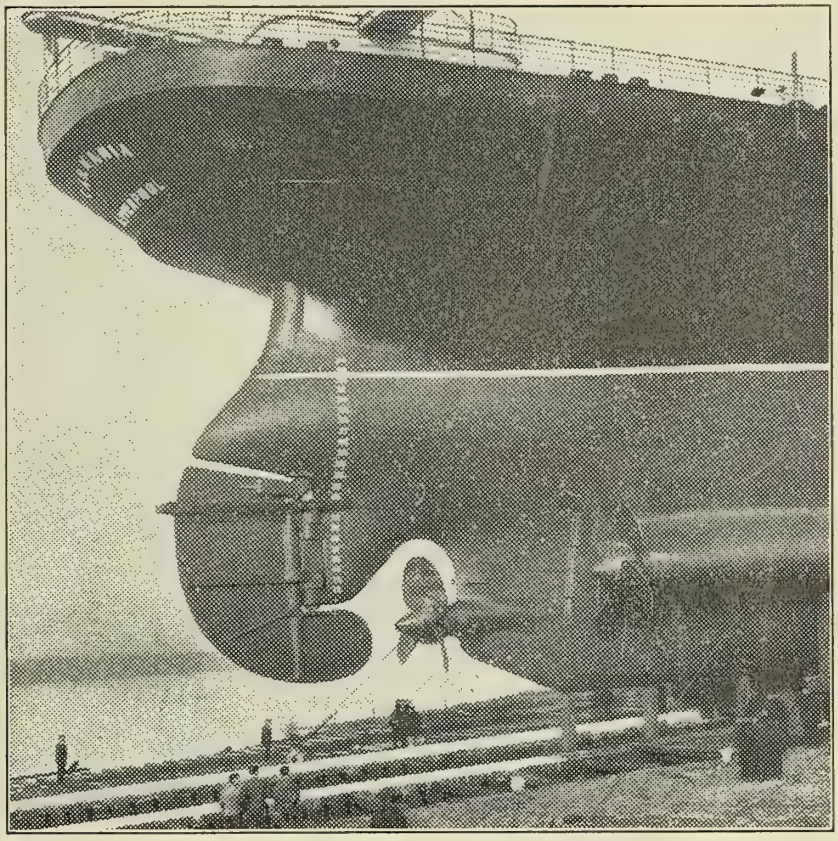
In this vessel the principle of driving the auxiliary machinery by electric motors has been developed to a considerable extent, and special attention has been given to the disposition of fans for the ventilation of the extensive passenger compartments. The navigating and deck machinery is necessarily of a powerful character. There are two steering engines of very heavy proportions, one under the waterline, so that there is little chance of this important item of the navigation of the ship being affected by gunshot when the vessel is used as an armed cruiser; the other steering engine is placed on a higher level. The rudder stock is extended up to the highest gear, but can be operated by either of the two steering engines. The capstan and windlass gear for working the heavy anchors are probably the heaviest that have been

fitted to any merchant ship. The navigating bridge is placed in a very high position, so as to command a wide circle, and the captain has, within arm's reach, apparatus whereby he can control every movement, both at sea and while entering docks.

The ship is of the following dimensions:

Length over all	678 feet
Breadth molded	72 feet
Depth to shelter deck	52 feet
Draft of water laden	32 feet
Corresponding deadweight cargo	12,000 tons
Displacement	29,800 tons
Gross tonnage	19,524 tons

one, two, or three passengers. A number of them are *en suite* with bathroom, while the more pretentious ones consist of bedroom, parlor, bathroom and toilet room. The *en suite* rooms are large and fitted with wide berths, ivory white paneling, velvet pile carpets, luxurious settees and armchairs, dressing tables, wardrobes, writing tables, bookcases and hot and cold water. Most of the staterooms are fitted with a spring sofa, a Pullman upper berth, and a wide lower berth, dressing table, wardrobe, writing table and easy chair. The berth curtains are of finest damask, and the carpets laid on the deck are a rich shade of red, which imparts a comfortable and cheerful appearance to these apartments. The rooms are well lighted, and the passenger can, at will, have a light at almost any place convenient to himself.



THE SHIP'S STERN BEFORE LAUNCHING.

There have been used in her structure 1,800,000 rivets and 12,000 tons of steel. Some of the plates are 32 feet long, secured by five lines of rivets; the keel is three inches in thickness; and there is a double bottom for water ballast to bring the ship to a draught that will obviate rolling or pitching. The total capacity for water ballast is 3,450 tons. Very deep bilge keels have been fitted for one-half the length, and there are twelve bulkheads across the ship, so designed that if any two of the compartments were flooded the ship would continue to float. The bulkhead doors are closed by the Stone-Lloyd system. The stern frame of the *Carmania* is a forging, weighing about fifty tons. She is built on the shelter deck principle, with eight decks, and has been specially built for the highest class of Lloyd's special survey, and also under direct survey to the requirements of the British Admiralty, as a transport and armed cruiser. She has two pole masts rigged on the fore-and-aft system, with derricks, spans and other appliances for dealing with cargo.

In the passenger accommodation is an admirable system of cabin distribution and arrangement. There is provision for 300 first-class passengers, 350 second-class, 1,000 third-class, and 1,000 steerage, a total of 2,650, and with 450 officers and crew, the total ship's complement will be 3,100. There are staterooms for

Electric bells are fitted at convenient points for each berth. The rooms on the upper promenade and promenade decks are fitted with electric heaters. The bathroom and toilet arrangements in the ship have received special attention, and are distributed throughout in the most convenient positions, a notable feature being the number of needle and shower baths which are fitted.

Commencing with the highest of the eight decks of the vessel —the boat deck—the first thing which strikes the visitor is the magnificent lounge, which is an innovation in this and her sister ship *Caronia,* and forms a special feature among the public rooms of the vessel. It is designed to afford a comfortable retreat, where gentlemen may smoke in the company of their lady friends, while a convenient buffet suggests possibilities in the way of tea, coffee, and light refreshments. The usual stiff ship seat in the room gives place to a luxurious divan fitted round the apartment and formed into nooks and bays. Easy chairs with comfortable head rests are supplied, and the general effect of the blue furnishings with the rich coloring of the Eastern rugs and subdued tone of the mahogany fittings, combine to produce an effect of elegance.

Underneath this is the upper promenade deck, and leading off the spacious main entrances are situated the writing room and

drawing room. The writing room is an exceedingly tasteful apartment, with the ceiling and bulkheading treated in delicate Adams style, all painted and finished ivory white, with the rich and luxurious furnishings carried out in a restful shade of soft green. The room, as its title implies, is fitted for writing purposes only, and the tables are designed with a view to securing for each person the privacy of one's own sanctum. Passing from the writing room through archways draped with sumptuous velvet hangings, the drawing room is reached. This room is also carried out in the Adams style, with the bulkheading exquisitely paneled and molded, broken by pilasters richly carved and fluted. The whole ceiling and bulkheading is finished in ivory white, with rose silk panels. The furniture of the room is carried out in dark mahogany. The rich carpet is of a soft green shade, and the settees and easy chairs are upholstered in velvet of delicate rose and green. A charmingly-designed mantelpiece, with hammered brass sides and canopy, adds to the interest of the room. The deep oriel bays at each side, with their inviting settees, easy chairs, and cosy corners, all tend to suggest that the passenger is at home rather than voyaging across the Atlantic. The aim of the designers has been to get away from the usual and stereotyped style of drawing room aboard ship, with its rows of stiff and uncomfortable seats. The silk hangings and silk panelings are exquisitely fashioned. The room is flooded with soft light from the flat circular dome above, with its tastefully designed leaded glass panels, quite in accordance with the decorations.

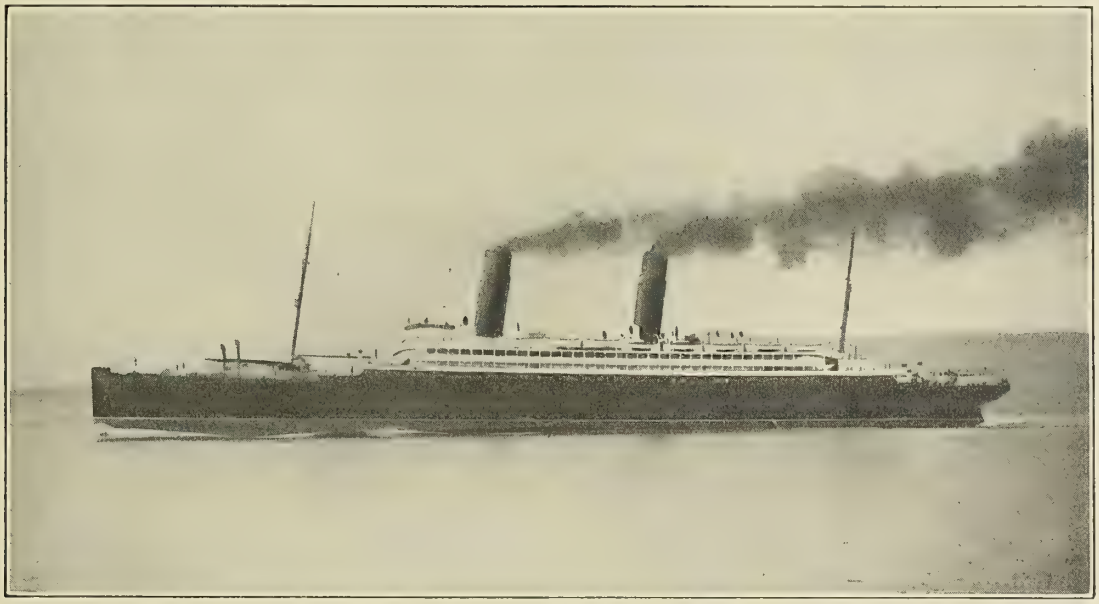
The first-cabin smoking room, which is aft on the same deck, is a room of more than usual distinction. The style employed is Elizabethan, and the result is most dignified and pleasing. The paneling is carried out in fumigated oak, with enriched and carved pilasters and pillars. The deck is laid with parquet, and the ceiling paneled in deep cream with oak molded beams. Rising from the ceiling in the center of the room is a flat-roofed dome with the sides paneled and carved and relieved by lacquered gold panels. The center of the dome is fitted with leaded lights, and the flat of the dome is picked out in gold. Here again the designers have effectively striven to produce a home-like effect, and the well-proportioned mantelpiece, with hand-beaten copper grate and open fireplace, which is surmounted by a semi-circular panel of hand-beaten copper, form a feature which is seldom met with on board ship. An unusually large assortment of easy chairs and lounges completes the furniture of this room, which has more the appearance of a comfortable living room in a country house than an apartment aboard ship. The upholstering is in mellow colors, which blend perfectly with the surroundings. The room is thoroughly lighted, not only from the square port windows on either side, but by the handsome skylight above.

The dining saloon, which is two decks beneath this, is arranged amidships, and extends the full width of the vessel, accommodating 300. The style employed in the decorations is Georgian, and the paneling to the room is all painted and finished ivory white. In the center of the room a large octagonal dome is arranged with the sides opening out on to the alleyways on the deck above; the sides, pillars, and ceiling of this dome are decorated in ivory white and enriched with gold, which forms a pleasing relief to the remainder of the saloon. The same decorative scheme, but in a higher relief, is shown in the frieze surrounding the entire saloon, which harmonizes perfectly with the capitals of the columns. Instead of the unbroken lines of tables fore and aft of the ship, these are broken up into small tables to suit parties of six, eight, ten, or twelve, as the case may be, with a circular table in the center of the saloon. The chairs, too, have had special attention, and instead of the usual heavy revolving chairs, there are fitted thoroughly comfortable chairs with shield backs. The floor is laid with polished oak parquet, and between the tables are laid runners of thick Wilton carpet, which tones with the rich wine color of the upholstery. The outlines of the room are broken by a number of alcoves, formed by graceful arches and pillars.

THE LOUNGE, ON THE BOAT DECK.

On the promenade deck, conveniently located, is a polished mahogany counter, in semi-circular form, surrounded by an ornamental brass railing and serving the purpose of the customary hotel office. In this department is a steel-lined safe-deposit vault, containing a safe wherein travelers' valuables may be deposited. Near here is a stenographic room, in charge of a stenographer. Throughout this deck, as well as the others, are to be noted the spaciousness of the passages and the breadth of the stairways. There is on this deck the barber shop, handsomely equipped, the doctor's room and consulting rooms, and other conveniences for passengers' uses.

The second-class accommodation is hardly inferior to that provided for first-class passengers. Indeed, the saloons and staterooms on this vessel are undoubtedly an improvement from all points of view on the first-class accommodation fitted on many vessels now plying across the Atlantic. The dining saloon is paneled and finished in ivory white, with soft blue coverings to the seats, and blue carpets. There is a handsome sideboard fitted at the forward end, and at the after end is a handsome piano. The chairs are set on revolving standards, and the general effect is most pleasing. This room also extends across the entire width of the ship, insuring both light and ventilation from the large square ports.



THE CARMANIA IN FREE ROUTE.

Immediately over this room are the second-cabin drawing and smoking rooms, provided with every comfort found in the first-class apartments, and different only in the degree of their luxuriousness. The drawing room is carried out in satinwood neatly paneled and treated in simple but effective manner with carved pilasters. The second-class library is located in this room, and is kept well supplied with the latest publications. This room also forms the writing room, and neat writing tables and armchairs are arranged. The seats and easy chairs are upholstered in blue tapestry, and the floor laid with soft blue carpet, which tones well with the quiet gold of the satinwood paneling.

The smoke room is fitted in mahogany, with seats covered in blue moquette arranged in bays round the room; deep easy chairs, armchairs, and tables are also fitted, and the room, with its carpet runners and rich mahogany paneling, presents an appearance at once comfortable and luxurious. The staterooms are arranged in two and four-berth rooms, with fittings similar to those of the first-class staterooms; the rooms are notable by reason of their size, and are fitted with wide spring berths, comfortable sofas, fold-up lavatory fittings with dressing glass above, large wardrobe well supplied with hooks, berth curtains of cheerful patterned material, and carpet of rich red color.

It is open to question whether greater improvement has not been made in the third-class accommodation than in the first and second classes. A fine dining hall is fitted amidships to accommodate 500 persons at once. The sides are paneled with American ash and a teak dado. The tables are fitted with revolving chairs, and a piano, sideboard, etc., are provided. There are smoke rooms fore and aft, ladies' rooms fore and aft, all paneled to accord with the dining hall, and fitted with comfortable lounge seats and tables. The stateroom accommodation is provided in two-, four- and six-berth rooms, all large and airy rooms, provided with washstands, dressing glasses, seats and hooks. Arrangements are made by which the whole of the air in the third-class passenger spaces will be changed entirely every five minutes; with this great advantage, that in cold weather the fresh air will be warmed and in hot weather the air will be cooled by a special process. The sanitary arrangements are ample and of the latest and most up-to-date description. Baths are provided on a scale not before attempted, and in addition there are a number of shower baths for the use of the men, an innovation which was carried out in the *Caronia,* and which has been an undoubted boon to the third-class passenger.

Victualing is one of the most important items at sea, and the arrangements on the *Carmania* are as perfect as can be. The galley is the largest yet made, and every device which science has evolved has been requisitioned to secure to the passengers that the food supplied shall be well cooked. Perfect cleanliness is everywhere aimed at, and in no department is this so noticeable as in those where food is prepared and served. Potatoes are peeled by machinery, and thus handling is obviated. Dishes are washed by mechanical means, three Vortex plate-washing machines, capable of dealing with 8,000 pieces an hour, being provided for this purpose. In latter-day culinary methods steam

THE FIRST-CABIN SMOKING ROOM.

enters very largely into cooking processes for vegetables, etc., and to insure that the steam used in the galley of the *Carmania* shall be absolutely free from contaminating matter, which might occur in steam taken from the main boilers, a separate steam generating plant is provided in the galley. The same cleanliness obtains in the baker's shop, in the pantry, and the fact is characteristic of the whole of the cuisine arrangements for passengers. Among other devices which are to be found in the galleys are machines for making sandwiches, for cutting bacon, and also for boiling eggs. Some difficulty has hitherto been experienced in providing passengers on shipboard with fresh toast, but on the *Carmania* this has been overcome by the provision of a special toasting fire, which is quite a novelty. Testimony to the efficiency of the fittings of the cuisine department is afforded by the fact that the kitchen and cooking plant have been supplied by Henry Wilson & Company, of Cornhill, Liverpool, a concern which holds the remarkable record of having fitted every first-class British-owned passenger steamer built for the Atlantic trade during the last twelve years.

The latest safety device to be incorporated in the *Carmania* and other Cunard ships is the new system of submarine signaling. It is electric and telephonic, and by it signals can be transmitted under water between steamships and light vessels or from ship to shore. These signals work perfectly in cases of fogs when visual signals are useless. Many lightships are being equipped with submarine bells, and in thick or foggy weather these sound continually the known signal of this particular vessel. Approaching steamships provided with this apparatus are enabled to ascertain their exact location at all times and under all conditions. The sound of the bell, as heard on the steamship, indicates its direction and—by the intensity—its approximate distance, water being a constant medium.

An approved system of forced draught is adopted, as well as noiseless ash-lifts and various other features. The illumination of the ship is, of course, by electricity. To do this four large dynamos of 750 amperes and 100 volts are required, and the light is transmitted through more than 3,000 individual lamps and a powerful searchlight. Another important installation is the refrigerating machinery and cold storage. This is one of the largest plants ever placed on board ship, was installed by the Liverpool Refrigerating Company, and is operated on the ammonia system.

As the *Carmania* marks a new epoch in the Cunard Company, we note below the various stages of development in the fleet:

	Date	Make	Length	Tons	H.P.	
Britannia	1840	wood	207	1,154	740	paddle
Persia	1855	iron	376	3,300	4,000	"
China	1862	"	326	2,539	2,850	screw
Servia	1881	steel	515	7,392	9,900	"
Lucania	1893	"	600	12,952	26,000	twin screw
Carmania	1905	"	675	19,524	20,000	turbine

The *Carmania* completed her trials on the Clyde in the third week of November, 1905, before proceeding to Liverpool to load. The completion of these trials renders possible a direct comparison between the marine steam turbine as fitted in the *Carmania* and the reciprocating engine, as fitted in the *Caronia,* which has now been running on the Atlantic for some time. In this respect they may be called epoch-making vessels, from which naval architects and engineers will be able to draw many lessons.

The trials on the Firth of Clyde consisted of four runs on the measured mile at Skelmorlie, and a six hours' run. The contract required that a speed of nineteen knots should be maintained on the latter. On the four runs on the mile the speed was 20.19 knots, although the ship had not been docked since she was launched in February, and was very foul below the waterline. Allowing for that, the *Carmania* is fully 1½ knots in excess of the guaranteed speed, and one knot in excess of the *Caronia.* The contract further required that after an interval, determined by the directors of the company, the vessel should run a second six hours' continuous trial at contract speed, and this trial the *Carmania* steamed on the Firth for the stipulated time, the distance being measured by chart. High speed was not aimed at, and the rate all through was a little over 19 knots.

The *Carmania* steamed more easily than the *Caronia,* yet the machinery of the *Caronia* was a development of that of the *Saxonia,* proved by the Naval Boiler Committee to be the most economical steamer then afloat. If the *Carmania* improves on the *Caronia's* economy, she will be a very economical vessel. In maneuvering, the *Carmania's* efficiency was proved by the incident of a slight mishap to the steering gear, when the propelling machinery only was available for steering purposes, and the ship was satisfactorily steered by means of the turbines. On the measured mile trials at full speed the turning circle of the *Carmania* was considerably less than that of the *Caronia.* There was an instrument for testing not only horizontal but also vertical vibrations, and the records taken showed that the vibration in the *Carmania* was exceedingly slight.

The ship left Liverpool on her maiden voyage December 2, 1905, and reached New York December 10, having made the passage in 7 days 9 hours 31 minutes, or at the mean rate of 15.97 knots for the 2,835 miles.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, report under date of December 10, 1905, the following percentage of completion of vessels building for the United States Navy:

			Nov. 1.	Dec. 1.
BATTLESHIPS.				
Virginia	19 knots.	Newport News Co.	95.31	97.
Nebraska	19 "	Moran Brothers Co.	82.	83.
Georgia	19 "	Bath Iron Works	89.	90.15
New Jersey	19 "	Fore River Shipbuilding Co.	92.1	93.7
Rhode Island	19 "	Fore River Shipbuilding Co.	95.	98.
Connecticut	18 "	Navy Yard, New York, N. Y.	91.3	92.66
Louisiana	18 "	Newport News Co.	89.25	92.56
Vermont	18 "	Fore River Shipbuilding Co.	65.8	68.7
Kansas	18 "	New York Shipbuilding Co.	64.9	67.7
Minnesota	18 "	Newport News Co.	75.41	77.1
Mississippi	17 "	Wm. Cramp & Sons.	43.31	45.74
Idaho	17 "	Wm. Cramp & Sons.	39.19	42.58
New Hampshire	18 "	New York Shipbuilding Co.	25.	29.2
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works.	84.3	86.2
South Dakota	22 "	Union Iron Works.	83.2	84.9
Tennessee	22 "	Wm. Cramp & Sons.	87.8	90.02
Washington	22 "	New York Shipbuilding Co.	87.9	89.4
North Carolina	22 "	Newport News Co.	23.13	26.77
Montana	22 "	Newport News Co.	19.21	22.29
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	81.28	83.62
Milwaukee	22 "	Union Iron Works.	84.01	86.
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works.	9.	13.27
Birmingham	24 "	Fore River Shipbuilding Co.	12.6	15.4
Salem	24 "	Fore River Shipbuilding Co.	12.3	14.8
SUBMARINE TORPEDO BOATS.				
Submarine No. 9		Fore River Shipbuilding Co.	30.6	43.5
" " 10		Fore River Shipbuilding Co.	29.	36.9
" " 11		Fore River Shipbuilding Co.	29.3	37.
" " 12		Fore River Shipbuilding Co.	25.	33.6

There has just been launched at Orange, Texas, a floating drydock in a single-box section, the length over all being 332 feet; the length of the box, 242 feet; the width, 95 feet; depth of box, 14 feet; depth of water over entrance sill when submerged, 23 feet; capacity, 5,000 tons. This was built by the New Orleans Dry Dock and Shipbuilding Company, and will be operated by them at New Orleans. It has been built of the finest quality of yellow-pine timber in long lengths averaging about 60 feet. The logs for this timber were cut by the Latcher & Moore Lumber Company, and floated down the Sabine River from Calcasieu County, La.

THE EVOLUTION OF THE LIFEBOAT.

BY CAPT. C. H. M'LELLAN, INSPECTOR AND SUPERINTENDENT OF CONSTRUCTION, UNITED STATES LIFE-SAVING SERVICE.

The self-righting and self-bailing lifeboat of to-day is not a recent invention, as many magazine and newspaper articles of recent date would lead one to suppose. The origin of the lifeboat, or a boat especially designed to save life, dates back to the year 1785, when one Lukin, a coach builder, of London, built a boat having a deck with air spaces below the deck and at the sides and ends, with projecting gunwales of cork, and an iron keel to give it the desired stability. Several boats were built from Lukin's design, and are reported to have saved many lives on the English coast. The boat was not self-righting nor self-bailing. Lukin died in 1834 at Hythe, Kent, England, and the following inscription is still to be seen on his tombstone in Hythe churchyard:

> "This LYONEL LUKIN was the first who built, and was the original inventor of that principle of safety by which many lives and much property have been preserved from shipwreck; and he obtained for it the King's patent in the year 1785."

No great improvement was made upon the Lukin boat until the year 1852, when, because of many wrecks and much loss of life on the English coast, the Duke of Northumberland offered a prize of one hundred guineas for the best model of a lifeboat, and five officers of prominence of the line and construction corps of the Royal Navy were selected as judges. Two hundred and eighty models were sent in from the United Kingdom, France, Holland, Germany and the United States, to compete for the prize, which was won by Mr. James Beeching, of Great Yarmouth, his model being of the self-righting and self-bailing type. The judges, however, were not entirely satisfied with the Beeching boat, and requested Mr. James Peek, assistant master shipwright of the Woolwich dockyard, to examine the various competing designs once more, and to embody as many of the good qualities of the best plans as possible, into a new design, and the present 34-foot self-righting, self-bailing lifeboat is the result, with such improvements as the years of service since have suggested.

When the United States Life-Saving Service was reorganized in 1872, one of the self-righting lifeboats was purchased from the Royal National Lifeboat Institution of Great Britain, and the lifeboats of the service have since been built practically upon the same principle, with some minor changes which are considered improvements.

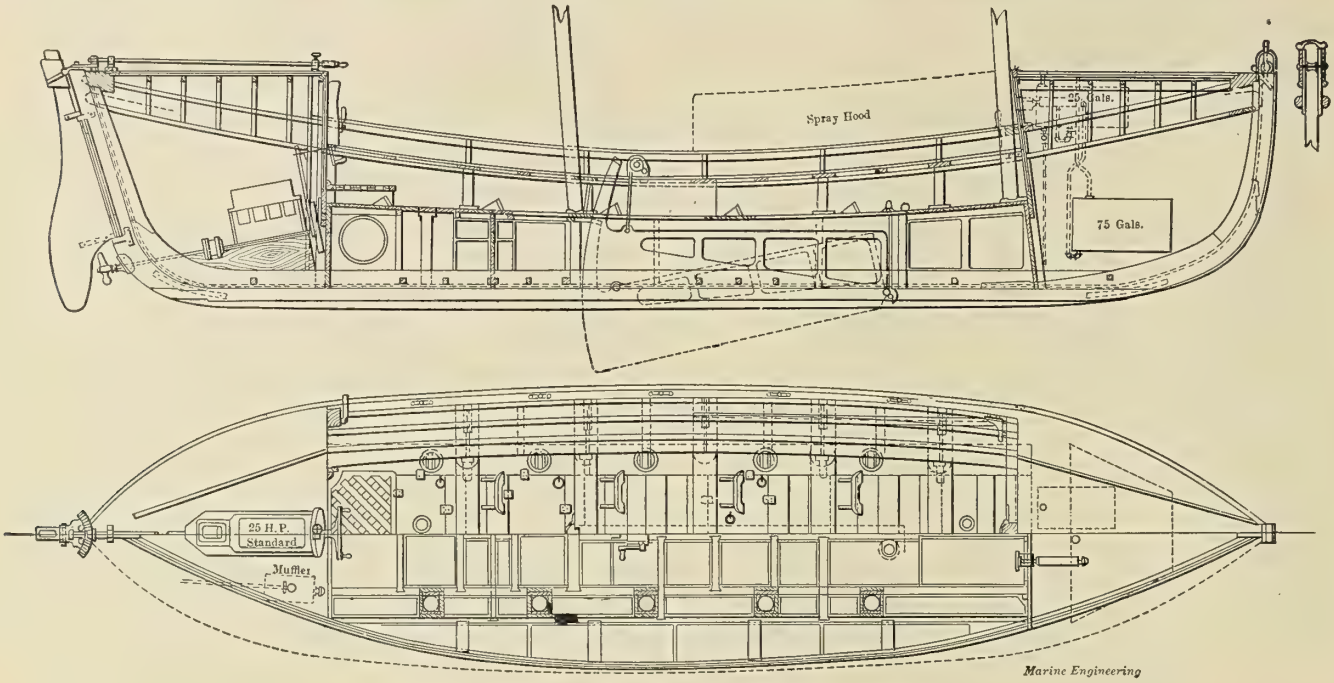
A lifeboat should combine the following qualities to the greatest degree possible: Extra buoyancy, stability, self-bailing, self-righting, passenger accommodation, strength, speed; and no boat has yet been brought to the attention of the officials of the Life-Saving Service which combines in so great a degree the above qualities, as the 34-foot service lifeboat recently completed by the Electric Launch Company, of Bayonne, N. J., from plans furnished by the government.

This boat is made unsubmergible by means of a deck at the load waterline, and three cross bulkheads and two longitudinal bulkheads below the deck, the watertight spaces within these bulkheads being completely filled with copper air-tanks, eighty-two in number. Additional buoyancy is also obtained from the end air cases, which, though chiefly intended to assist in the self-righting quality, will alone support the boat if it be filled with water, and also from the side air cases on deck under the side thwarts, which are intended to throw any water coming on board to the amidships emptying tubes. It is estimated that the buoyancy of the end air cases above the line of flotation is 4½ tons; that of the side air cases on deck, 1½ tons, and of the spaces below the deck, 5½ tons. A load of forty-four men taken from the works of the builder brought the deck scuppers awash.

THE BOAT UNDER SAIL, WITH PROTECTIVE HOOD IN PLACE.

Lateral stability or stiffness is of more importance in a lifeboat than in any other type of boat, since, from its work in the surf, it is more exposed to the risk of upsetting. This is obtained in the boat in question by the outside gunmetal keel before referred to, the gunmetal centerboard and the copper tanks in the air spaces below the deck. The end air cases or chambers also offer strong resistance to an upset when the boat is thrown on her beam ends. These, with a long, flat floor, give the boat greater stability than any other boat of its size that has ever come under the observation of the writer. In recent tests it required 3,300 pounds of pig lead, placed upon the gunwale, to bring the gunwale awash.

The self-bailing or discharge of the water is a peculiar feature of this lifeboat, enabling any water which may be shipped over the rail or taken on board by being thrown on her beam

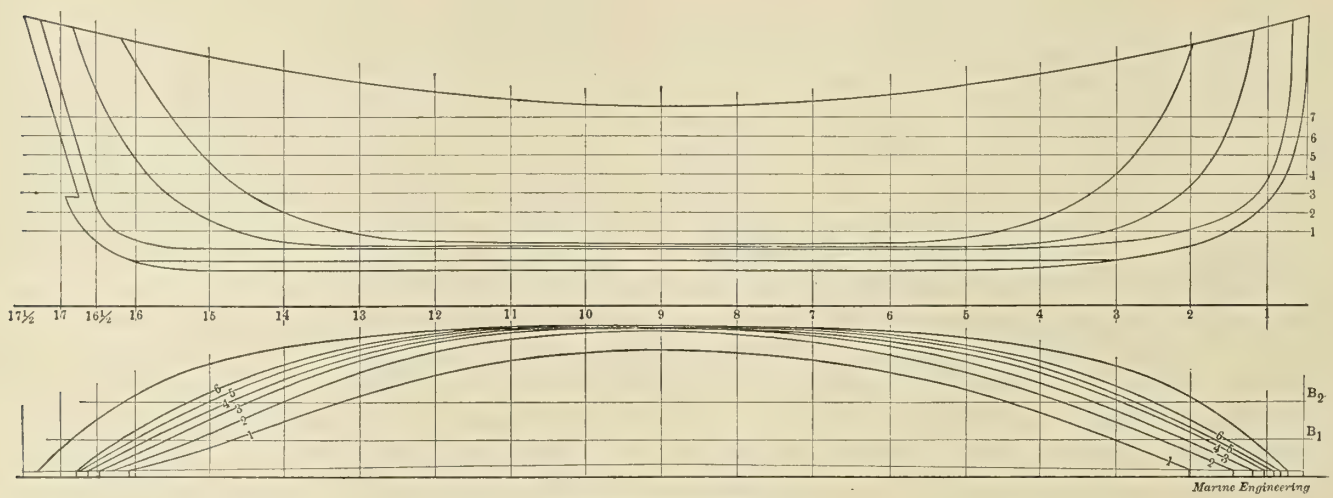


INBOARD PROFILE, AND ARRANGEMENT PLAN OF NEW LIFEBOAT.

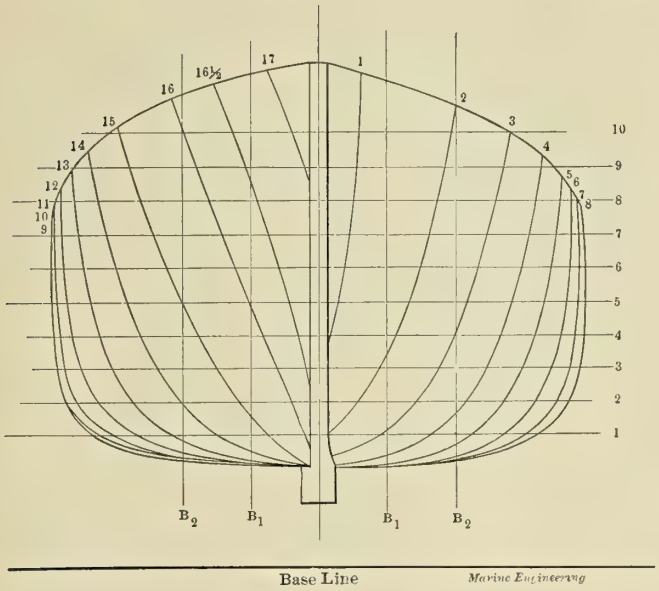
ends, to escape overboard in a few seconds. This self-bailing quality is accomplished by a deck placed above the load water-line, and ten six-inch copper tubes, five on each side of the deck, opening on the outside of the bottom of the boat, the upper ends at the deck being fitted with self-acting valves. These valves have a plate fitted in the upper ends of the tubes, turning upon an axis on one side of its center, so balanced as to remain shut of itself, the larger half seating against a shoulder above the valve, and the smaller half having its seat below the valve, so that it is opened by the slightest weight of water upon the larger half from above, and shuts still closer from any pressure of water or air from below.

The boat is made self-righting by giving it considerable gunwale sheer, two feet four inches amidships, and by air cases or chambers at each end, six feet long, of the height of the ends, and continuing their length parallel with the waterline, having sufficient cubical contents from the thwarts upward to bear the whole weight of the boat when inverted or bottom up in the water. When the boat is forcibly held in the water with the keel uppermost, it is floated unsteadily on the bow and stern air cases, while the heavy gunmetal keel, weighing 1,050 pounds, the metal centerboard weighing 750 pounds, and the copper air cases in the hold weighing 900 pounds, being then above the center of gravity, effects an unstable equilibrium, and the weight, falling on one side or the other of the center of gravity, rights the boat to her ordinary position; while the water shipped during the upset is thrown amidships by the side air cases and quickly escapes through the eight bottom bailing tubes. The raised end air cases or chambers are a great factor of safety to a lifeboat by preventing all water or other weights from loading the boat at either end, and by keeping water from breaking over the boat at the bow or stern, and giving a great resisting power to the submersion of the ends. The arrangement of the air cases forming the extra buoyancy is such as not to interfere with the passenger carrying properties of the boat.

There is no other boat of its size that is exposed to such hard usage as a service lifeboat. It is liable to be thrown heavily upon the beach or rocks, or against a vessel's side, or to come in contact with floating wreckage. To guard against serious injury from such causes, no pains or expense are spared in its construction. The specifications call for the very best material and workmanship. The best of white oak is used for the keel,



THE LINES AND BUTTOCKS.



THE BODY PLAN.

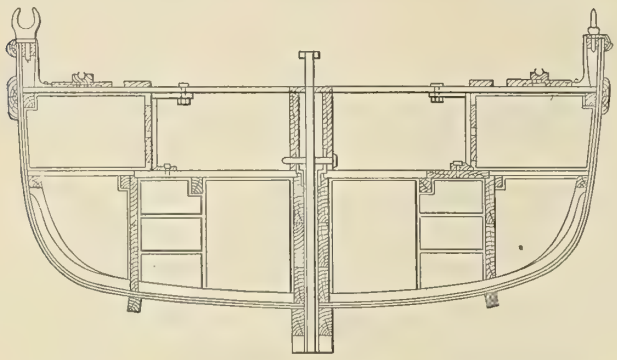
keelson, stem and stern posts, the latter, root knees. The planking is of ⅜-inch clear Honduras mahogany in two layers, laid diagonally across each other throughout at an angle of 45 degrees with the keel amidships, each plank not to exceed seven inches in width, and extending in one length from gunwale to gunwale on opposite sides of the boat to within eight feet of each end, and thereafter in one length from rabbet to gunwale.

keelsons, one on each side, of 1½-inch yellow pine, extending the whole length of the space between the end air cases, from the skin to the deck, forming longitudinal watertight bulkheads. Three athwartship bulkheads of the same material are dovetailed into these bilge keelsons. The spaces between the bulkheads and bilge keelson, and between the skin and deck, are filled with

BOW VIEW OF BOAT UNDER SAIL.

THE BOAT UNDER POWER, WITH PROTECTIVE HOOD FURLED.

Between each two layers of planking is a covering of 10-ounce cotton duck laid in white lead and oil, and both layers of planking copper riveted through and through. The outside keel is bolted through the keelson and planking with composition bolts, and below the keel is bolted the gunmetal keel, three-inch deep siding like the wooden keel. A strong feature of the construction is the fenders of white oak, six inches wide and two inches thick in one length, extending from stem to stern, fastened through and through the risings. There are two inside bilge eighty-two close-fitting, watertight, copper tanks, shaped to the spaces they occupy, all of which can be removed through the hatches in the deck. The deck is of mahogany, laid in the most substantial manner. The centerboard is of gunmetal. There are two hollow spruce spars, with sprits, sails and one jib, and ten 15-foot oars, double banked. A unique steering gear is so arranged that it can be instantly disconnected from the rudder head, permitting of the rudder being hoisted out of the water by a purchase always in place, thus enabling the boat to be



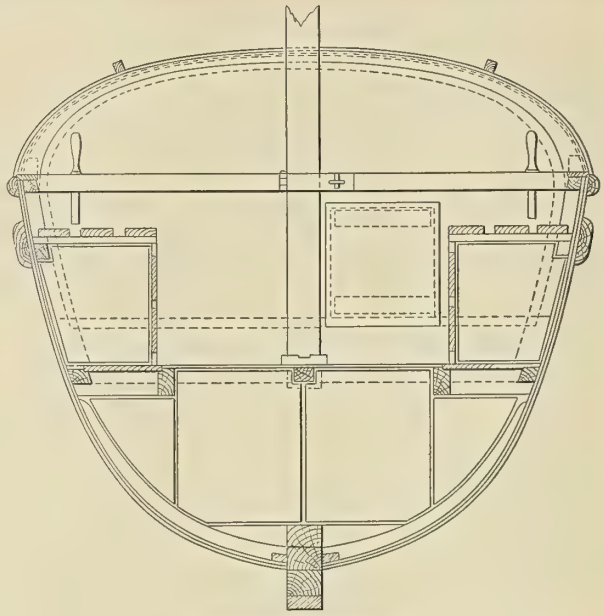
Section Amidship *Marine Engineering*

steered by sweeps when entering a broken surf where it would be unsafe to steer by the rudder. A spray hood for protection in freezing weather covers a portion of the deck, and folds snugly against the forward air chamber when not in use.

In addition to the above means of propulsion, a gasoline automotor has recently been installed. The officials of the United States Life-Saving Service have been prompt to recognize the advantage in power and lighter weight afforded by the gasoline automotor, and are installing them in the 34-foot class of self-righting service lifeboats described above. This class of boat is about the maximum in size and weight that can be advantageously handled by the regular crew of a life-saving station with oars or sails, and to install a heavy motor in them would necessitate either increasing the dimensions of the boat to an unmanageable size, or reducing the passenger capacity of the boat. Several of this class of lifeboats were fitted with the ordinary gasoline engines several years ago, and while they have been a pronounced

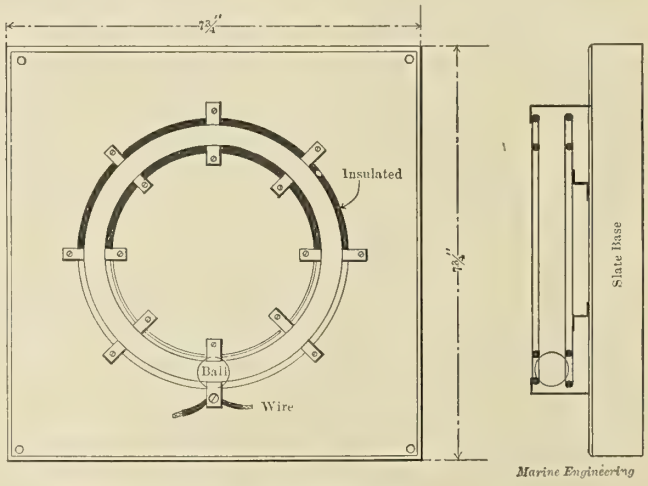
QUARTER VIEW, BOAT AT REST.

improvement and have added greatly to the efficiency of the boat, the loss in carrying capacity, because of the great weight of the motor, has been severely felt. At the time the boats above referred to were fitted with the gasoline engines, the lightest 12-horsepower engine obtainable was about 1,200 pounds in weight, which with the fittings amounted to nearly 1,500 pounds. At the present time the same class of boat is being equipped with a 25-horsepower "Standard" automotor which, with its fittings and fuel, has a weight of less than one-half of the old equipment, and with a large increase of revolutions and speed. This motor is installed in the after air case, and drives an 18-inch three-bladed propeller 900 revolutions. The main fuel tank, holding seventy-five gallons, is in the bottom of the forward air case, with an auxiliary tank holding twenty-five gallons in

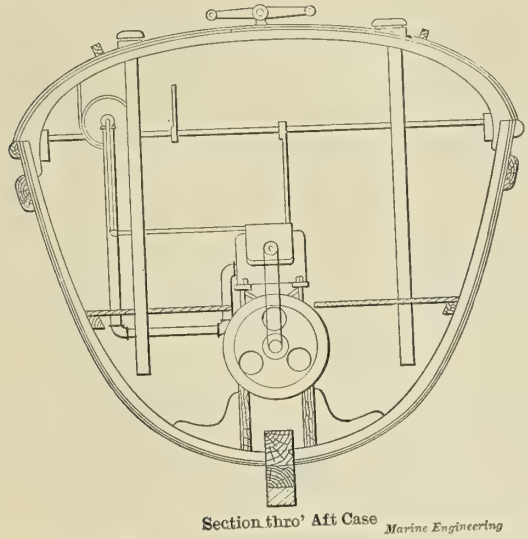


Section at Fwd. Blk'hd *Marine Engineering*

the top of the same case, into which the fuel is pumped as needed from the main supply. This arrangement carries the principal weight of the fuel low down in the boat, while the height of the auxiliary tank gives sufficient fall of fuel to the motor in the roughest sea. The fuel is led to the motor through a brass pipe let into the keel outside of the boat. All of the attachments for running the motor lead to the outside of the bulkhead of the after air case, and are protected in sleeves from accident by rope, oars, etc. In case of an upset, the motor is automatically stopped by breaking the circuit of the sparker, by an ingenious device designed by the Electric Launch Company, and shown in the accompanying diagram. It consists of four metal rings forming a circular cage upon a slate base in which travels a brass ball. As this circuit breaker is placed in the boat on a vertical plane, the top section is insulated from the lower section, the amount of insulated area depending upon the angle at which it is desired to have the ignition circuit of the motor cut off, and, therefore, can be varied as required. In the case of the boat in question, the upper half is insulated, the lower half uninsulated, and in this section the ball travels. The ignition circuit of the motor is so arranged as to have this cage in series with the battery and sparking points. In case of an upset when the boat is upon her beam ends, the ball rolls to the insulated portion and, therefore, opens the ignition circuit. The electricity is conducted through the metal ball and rings. As far as we know, this is the first time this form of circuit breaker has ever been used,

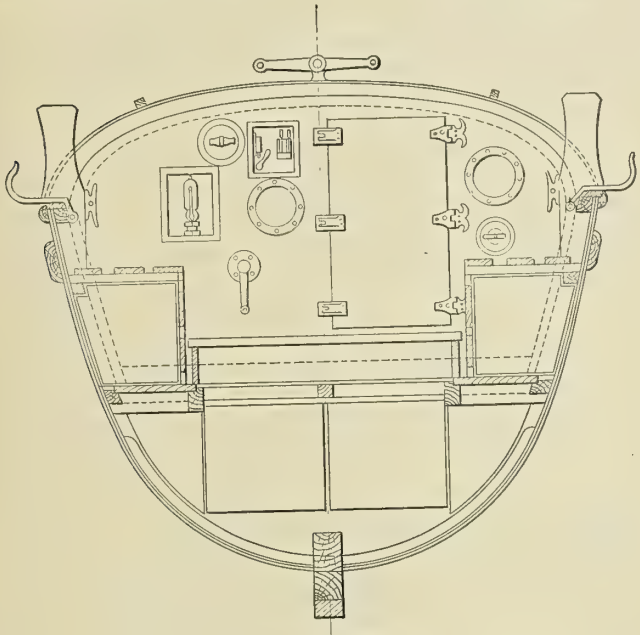


THE CIRCUIT BREAKER.



Section thro' Aft Case *Marine Engineering*

and we believe it the simplest scheme that has yet been devised. In the capsizing tests made with the boat, in which a crane was necessary to throw it over, the motor was running at full speed, and upon reaching the quarter point or on its beam ends, the circuit breaker stopped the motor. The boat being thrown bottom up instantly self-righted and emptied itself, and the motor was again started as soon as a man could reach the starting crank.



Section at Aft Blk'hd *Marine Engineering*

Recent tests of this boat for speed, endurance and carrying capacity have been most satisfactory, and it is believed that the present boat is as completely equipped for the work of the Life-Saving Service as it is possible to make it.

Proposed Legislation for the Merchant Marine of France.

The shipping law of 1902, which was intended to ameliorate the condition of the French merchant navy, has given but little satisfaction to either the ship owners or the shipbuilders of France. Although the life of the law was fixed at ten years, during the three years it has been in operation the maximum tonnage prescribed has already been registered, so that during the rest of the period the law will give no encouragement to build new vessels, as they cannot enjoy its benefits. The result is that a great stagnation prevails in the shipbuilding yards throughout France, thousands of men are out of employment, and the upbuilding of the merchant marine is checked. To relieve this critical situation, the shipowners and shipbuilders, through their representatives, agreed upon a measure which was presented to an extra-parliamentary committee appointed by the minister of commerce. The committee, after hearing those interested in the question, prepared a bill which has been approved by the minister of commerce, and will, in all probability, be brought before the present parliament. This being a short session, however, it is doubtful whether the measure will be discussed, as most of the time will be taken up in voting the budget.

SHIPPING BOUNTY.

The principal features of the new project are the suppression of the navigation bounty and the granting of a shipping bounty (compensation d'armement) to all vessels sailing under the French flag in the deep sea or in the international coasting trade, whether foreign built or constructed in France, provided the former are over two years old when they receive their French registers. The proposed bounty, per day the vessel is actually in commission and per gross ton, is for steamers, 4 centimes (0.772 cent) per ton up to 3,000 tons; 3 centimes (0.579 cent) for each additional ton between 3,000 tons and 6,001 tons; 2 centimes (0.386 cent) for each additional ton above 6,001 tons; for sailing vessels, 3 centimes (0.579 cent) per ton up to 500 tons; 2 centimes (0.386 cent) for each additional ton between 501 and 1,000 tons; 1 centime (0.193 cent) for each additional ton above 1,000 tons.

The bounty is given to those sailing vessels only whose gross tonnage is at least 100. There is a reduction of 15 percent when steamers, on their trial trips, half loaded, do not make an average speed of at least 10 knots. No bounty is given to steamers which do not make 9 knots. The bounty is increased 10 percent for steamers making 13 knots on their trial trips; 20 percent for steamers making 14 knots; 40 percent for steamers making 15 knots, and 80 percent for steamers making 16 knots.

CONSTRUCTION BOUNTY.

To compensate the French shipbuilders for the privilege granted to the shipowners to buy their vessels in foreign countries, a considerable increase is proposed in the construction bounties. For steel or iron vessels the projected bounties are, steamers, 145 francs ($27.30) per gross ton; sailing ships, 95 francs ($18.34) per gross ton. These bounties are reduced annually 3 francs (57.9 cents) for steamers and 2 francs (38.6 cents) for sailing vessels during the first 15 years the law is in operation. After 15 years the bounties will remain fixed at 100 francs ($19.30) for steamers and at 65 francs ($12.55) for sailing vessels. For vessels built of wood the bounties proposed are, ships of 150 tons or more, 40 francs ($7.72) per gross ton; ships of less than 150 tons, 30 francs ($5.79). If any change should be made in a vessel by which the tonnage is increased, the vessel is entitled to the construction bounty for the increased tonnage.

The construction bounty for boilers, engines, etc., is 27.50 francs ($5.31) per 100 kilograms (220.4 pounds), with an annual decrease of 50 centimes (9.65 cents) for 15 years.

In article 8 of the measure exception is made in regard to vessels engaged in a postal service which receives a subvention from the government. For this class of vessels the construction bounty is not increased, being the same as under the present law, 65 francs ($12.55) per ton for the hulls, and 15 francs ($2.90) per 100 kilograms (220.4 pounds) for the machinery, boilers, etc.

The life of the new act is fixed at 20 years from January 1, 1905. The tonnage of new vessels which can enjoy the benefits of the construction bounties is limited for steamers to 50,000 gross tons per year and for sailing vessels to 15,000 gross tons. The construction bounties granted by the new measure are reserved to vessels of which the hulls, machinery, and boilers were built in France; the shipping bounties to vessels which belong to French ports.

All the provisions of the laws of January 30, 1903, and April 7, 1903, which do not conflict with the new measure will remain in force.—*Daily Consular Report.*

GOLD DREDGES.

BY F. F. COLEMAN.

To one who casually examines a gold dredge it seems as though the designing and building of such a craft would be a simple proposition. This was evidently the impression which dominated the minds of those who constructed a large number of the dredges which are in use, and the failure of the designers to appreciate the necessities of the case has cost and is costing large amounts of money to the users. The mistake of the designers was in failing to appreciate the exceptionally arduous character of the work which a gold dredge is called upon to perform, the rapidity with which this work destroys mechanism not especially designed for the conditions, and the rapid reduction in the margin for profits which results from stoppages alone, leaving out of consideration the actual bills for repairs.

Considering the general character of the work, involving as it does the digging and handling of vast quantities of earth and gravel containing at the most but a few cents' worth of gold to the cubic yard, it seems almost a marvel that the industry could have been made to pay at all. As a matter of fact, gold dredging has not only come to be recognized as one of the leading features in gold mining in California and other sections where it has been introduced, but also one of the most profitable. It has even been predicted by men who have been closely in touch with gold-mining interests for years, that within the next ten years gold dredging will double the world's production of the precious metal. While this may be an over-enthusiastic view, there is no doubt that to-day it is the most rapidly growing and most attractive feature in gold mining, and that improvements in the machinery of the gold dredge are of the highest importance.

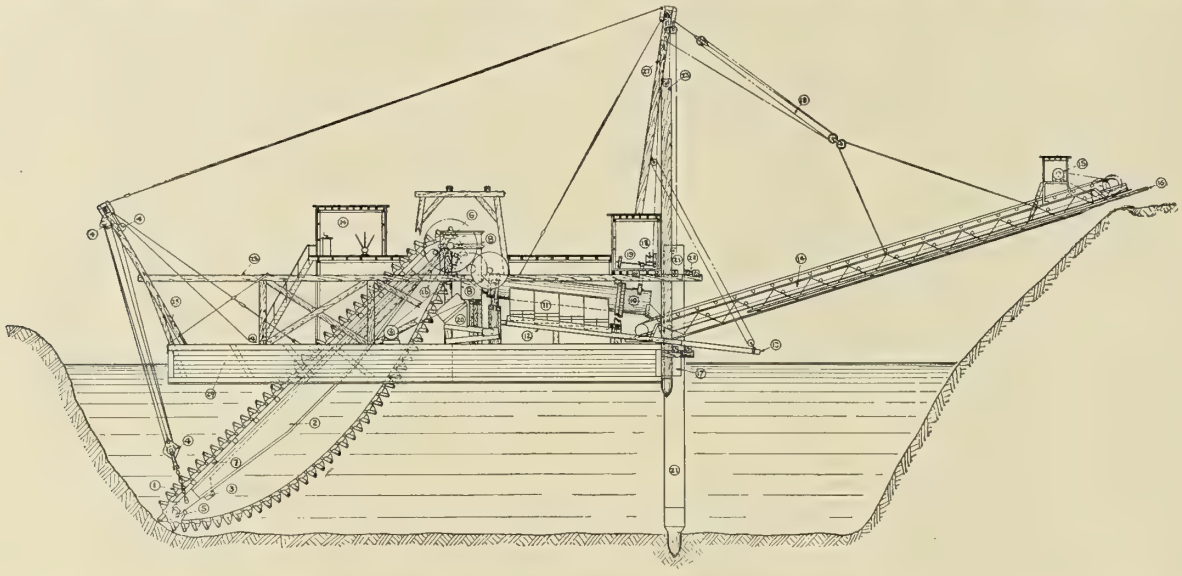


FIG. 1.—SIDE ELEVATION OF A STACKER GOLD DREDGE AT WORK.

The world has many thousands of acres of alluvial lands which contain gold in appreciable quantities. Some of this land is in the beds of streams or lakes, while much of it is high and dry. Some of that which is now being worked by gold dredges is land in cultivation covered with orchards and crops. Even the sites of villages and towns have been invaded by this most modern of gold seekers.

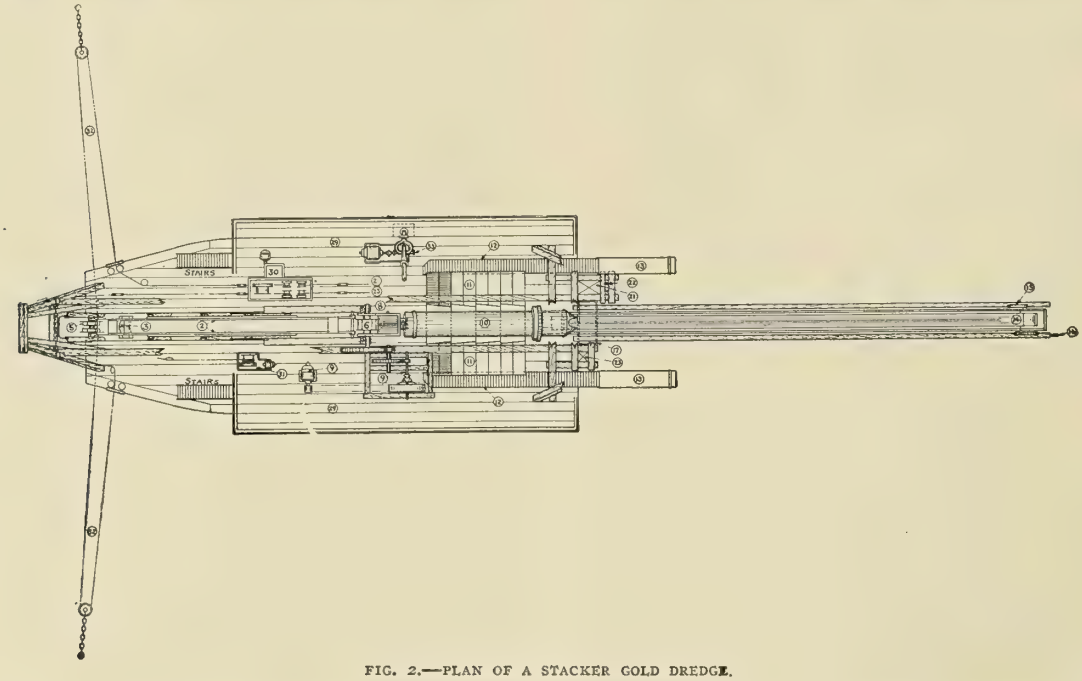


FIG. 2.—PLAN OF A STACKER GOLD DREDGE.

The gold dredge works and travels wherever there is water to be had to float it. This may be in the bed of a stream, a natural lake, or merely in a pool which the dredge itself digs as it advances and fills in again behind it. There must be a sufficient amount of water in addition to that which floats the dredge to

wash out the gold from the earth, but most of this returns to the pool to be used over and over again. In such places the dredge begins its career from a pit dug for it, in which the hull is built.

The dredge itself consists of a broad, rectangular hull of sufficient displacement to carry the machinery, with sometimes a float in addition to support the weight of a long sluice, astern. From the bow to nearly amidship the main hull is cut through in the center, forming a well. Through this well drops the ladder and bucket line which does the digging. This line and ladder is supported amidships by a main shaft which in some designs is also the shaft of the upper tumbler for the endless bucket chain. Its outer end is supported by and raised and lowered from a derrick which straddles the well at the bow and is seated on the hull on either side.

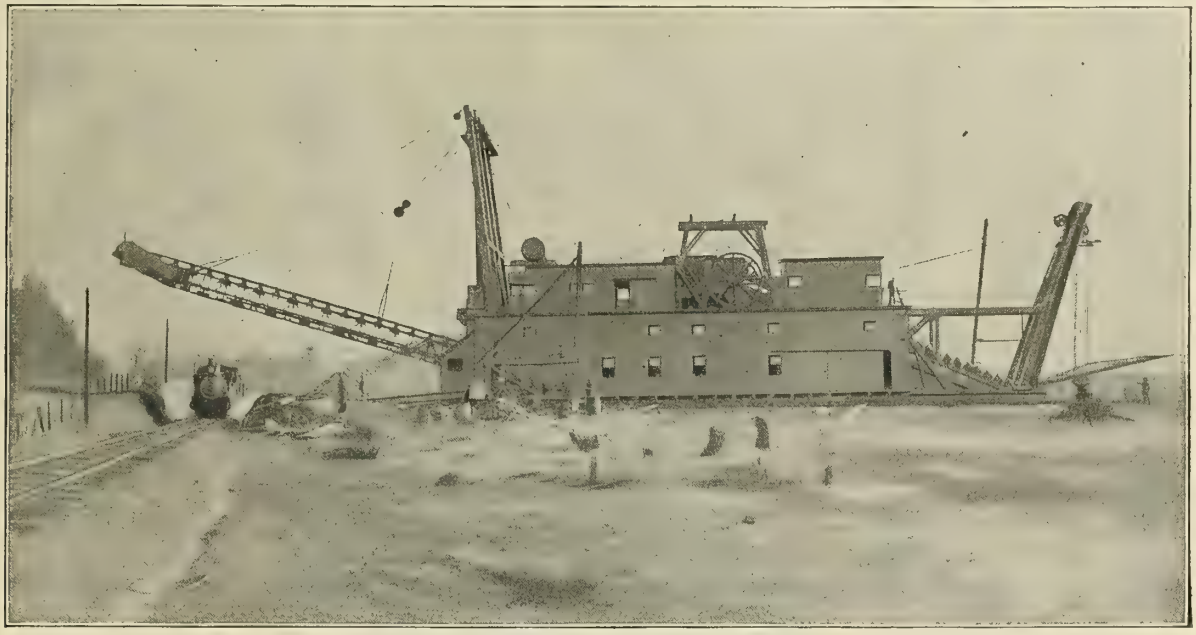


FIG. 3.—STACKER DREDGE READY FOR OPERATION.

The digging line and the gold-saving devices into which the buckets deliver the gravel are the two essential features of a gold dredge. All the other features are incidental. The hull may be handled entirely by lines or it may be provided with spuds; it may carry a complete steam-power outfit aboard—boilers, engines, and all—or it may derive its power from outside sources and use electric motors for every operation aboard. These details have their importance, and no wise person would order a gold dredge without having these points, as well as the more essential ones, determined by experienced and skilled gold-dredger engineers.

There are two general types of gold dredges—the "long sluice" or New Zealand type, and the "stacker" dredge or California type.

The form in which the gold occurs in the land to be worked determines which of these types is to be used. If it is in the common form of rough, irregular pellets, easily washed out and saved without especial care, the long-sluice dredge is the proper one. In this type the gravel from the dredge buckets is dumped into a hopper at a rate of about fifteen buckets per minute. From the hopper it goes into a revolving screen, where the finer material is washed out by means of jets of water sprayed over the mass, while the boulders and coarser matter are discharged overboard through an opening at the side of the boat. Where the ground is free from clay, shaking screens are often used instead of revolving screens.

Under the screen is a short sluice box where most of the gold values are caught. From there the material passes to a steel pump at the end of a short sluice, from which a centrifugal sand pump raises it to the inboard end of the long sluice leading to the dumping place astern. Any values which have escaped the riffles of the short sluice are caught in the long sluice. This form of dredge has the incidental advantage of leaving the ground behind it comparatively level, and with the coarser material deeply buried.

Where the gold is in smaller particles, but still of the character already described, such as that found in the Oroville district in California, the stacker dredge is the form required. Fig. 3 shows one of this type just ready to begin work. Instead of sluices to recover the gold, tables of a special form are used. Before the sand and gravel are passed over the tables, all the boulders are removed by a screen and the stacker takes these and deposits them in great heaps ashore. The stacker is merely a great steel truss boom swung from the stern of the dredge and carrying a conveying belt to dispose of the refuse. Figs. 1 and 2 show the plan and elevation of an Allis-Chalmers stacker dredge.

The gold is found mostly in gravels more or less cemented together. Beds of any thickness up to about 60 feet can be worked. The work of the bucket line is of the most arduous character.

FIG. 4.—ANOTHER STACKER DREDGE.

Good dredging grounds usually contain from 10 to 20 cents' worth of gold to the cubic yard. Those at Oroville are estimated to average about 16 cents. Of this from 75 to 90 percent is recovered.

The nearer a dredge can come to working 24 hours a day for

365 days in the year the more profitable its operations are likely to be. Whether a gold dredge will show a profit or not will depend largely on two conditions: delays, and cost of repairs. Figures gathered by careful observers in various fields show how important these items are. One typical table shows the following percentages of delays from various causes:

CAUSES	PERCENT	CAUSES	PERCENT
Bucket line	23.1	Frictions and winches	2.5
Upper tumbler	16.2	Holidays	1.8
Lower tumbler	8.3	Cleaning up	1.7
High water	15.6	General repairs	1.7
Conveyor	5.3	Electric machinery	1.5
Lines breaking and changing	4.8	Water pump	1.4
Shaking screen	4.5	Ladder and ladder hoist	1.3
Power off	4.5	Bolting	1.3
Oiling	3.8	Stones, rocks and stumps	.7

The parts to be dealt with are few in number. The proposition was therefore the more difficult. It consisted in finding the very best form for every part and employing for each the most durable material. Ease of replacements was as important as added durability. The principal features dealt with in making these improvements are the chain joints, the upper and lower tumblers, and the buckets. A new centrifugal water-lined sand pump has also been provided, which reduces the wear and the power required for operation to the lowest limits.

The weakest points in bucket chains have always been found in the eyes and pins. Bent or broken pins are sources of great loss of time. Subjected as the chains must be to serious wear it becomes necessary at frequent intervals to renew the pins. If the pins are not bent this may be accomplished rapidly with a chain which is otherwise well designed, but with bent pins it becomes a serious matter, and one that costs much time and money. It is not at all uncommon for operators using some makes of chains to have to remove two or three links together and send them to a shop, perhaps miles away, to get the old pins taken out and new ones inserted. The bending of the pins was due to the fact that in nearly all makes of chain there are only two eyes at each end of the links. This makes but two shearing points to a pin, and the pins are frequently broken, while the liability to bending is great. In fact, it is so great, that it is not uncommon to find pins as large as 5 inches in diameter used in some chains.

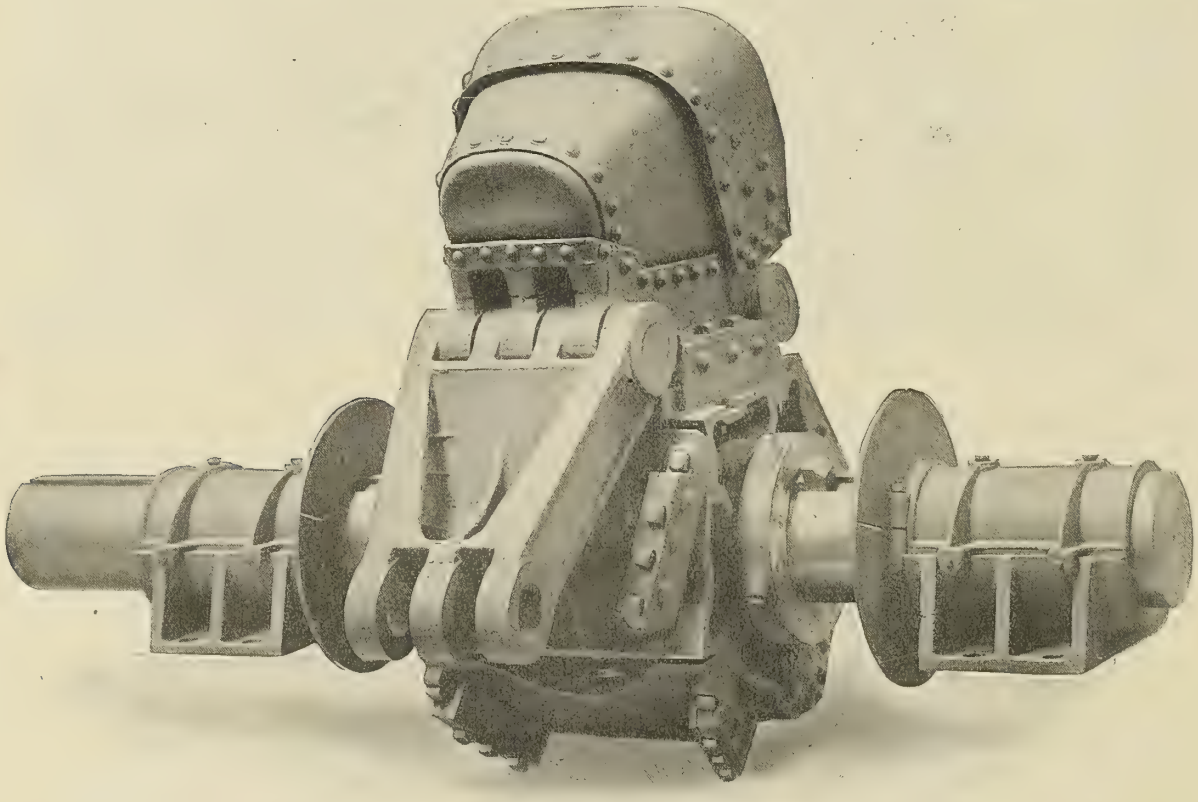


FIG. 5.—OPEN PATTERN DIGGING CHAIN, WEARING PARTS LINED WITH MANGANESE STEEL.

Another typical table shows the cost of repairs compared with other expenses. Its figures cover five different dredges. They cover the cost of operation per cubic yard in cents and fractions of cents:

DREDGES	NO. 1	NO. 2	NO. 3	NO. 4	NO. 5
Repairs	3.80	3.46	3.03	2.97	2.86
Labor	2.05	1.85	1.82	2.33	1.64
Power	1.77	1.15	1.20	1.61	1.06
General	0.73	1.23	0.67	1.28	0.64
Total	8.35	7.69	6.72	8.19	6.20

These figures show that an average of a little more than 43 percent of all expenses goes for repairs. The greater portion of the expense of repairs as well as the bulk of the delays in operation are traceable directly to the bucket line and its adjuncts. It was to meet these conditions and to reduce the two sources of chief expense to the lowest possible limits that the Allis-Chalmers Company set its experts to work.

The Allis-Chalmers chain has seven eyes at each joint. Three are on one end of each link and four on the other end. This form of link gives greater strength and stiffness to a 2-inch pin than a 5-inch pin has in the ordinary chain. The pin has six shearing places where the ordinary make has but two. The eyes are protected from wear by manganese steel bushings, which fit so tightly into the links that they cannot turn. The pins fit loosely in the bushings so that they may turn freely. They are of soft steel and receive the wear. By being allowed to turn freely the wear is distributed evenly so that the pins are not cut into deep grooves as is common, making it difficult to remove them for renewals.

The buckets have also received needed attention in design, to give them the necessary material for wear where they come in contact with the tumblers, and their tips are protected by manganese steel against the wear of digging. They are shaped so as to allow them to take up full loads, and to entirely empty themselves into the screen hopper. They are made watertight to prevent loss of sand and gold through leakage.

Next to the bucket line the part which is ordinarily responsible for the greatest amount of trouble is the upper tumbler.

There are often reasons for using tumblers which differ from one another in the number of their faces and other particulars, but for general purposes a six-sided tumbler is used. This is fitted on a square shaft. The load on the tumbler is constantly changing, often from almost no load to the full capacity of the machine and back again in a moment or two. With round, keyed shafts this is disastrous, batting up the keys and loosening the tumblers. The large flat surfaces of the square shaft have proved much better adapted to the work than any other form. Every portion of the tumbler where wear could come is protected with renewable manganese steel plates. One form of the Allis-Chalmers upper tumbler is shown in Fig. 5.

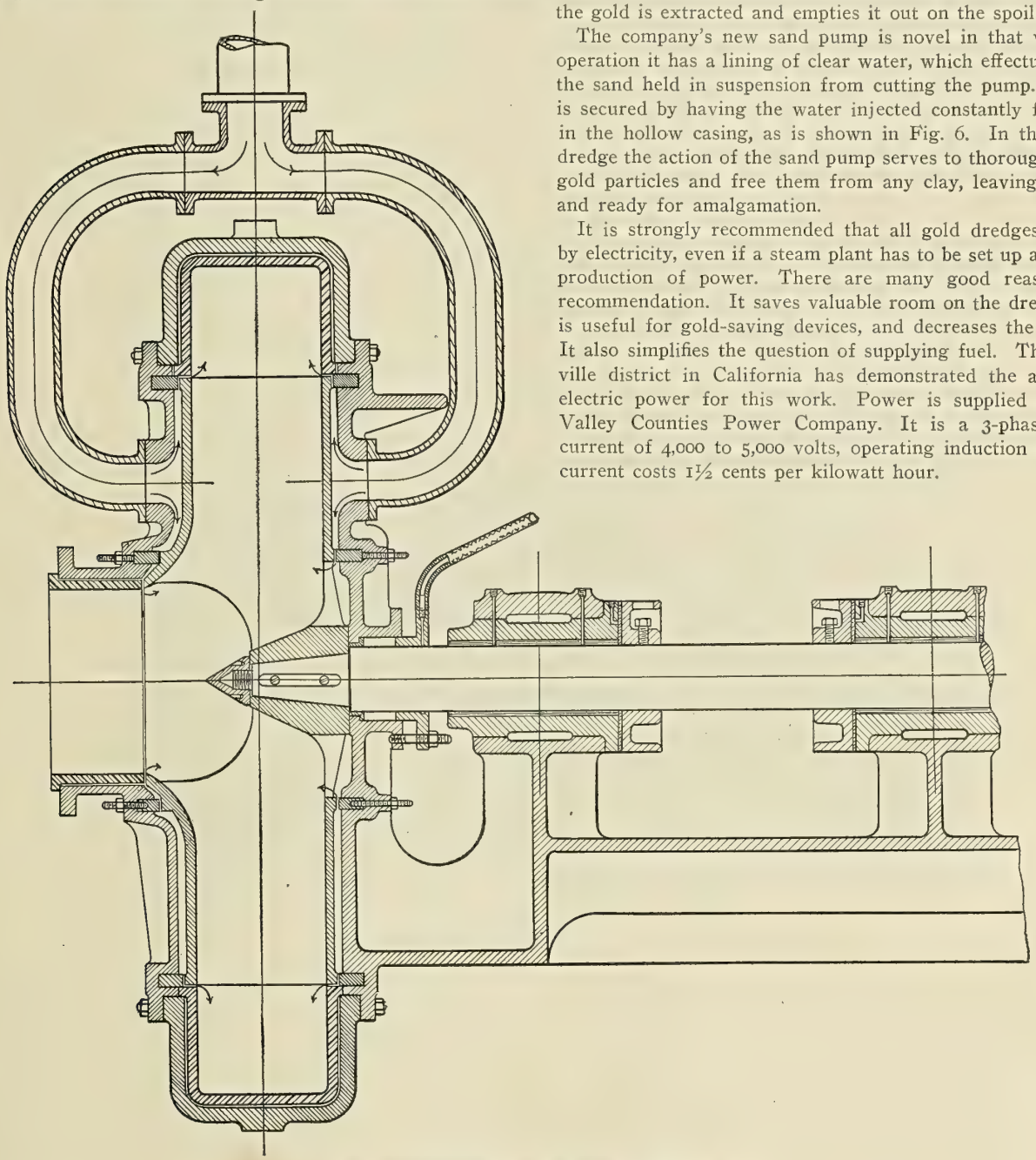


FIG. 6.—WATER-PROTECTED CENTRIFUGAL DREDGING PUMP.

The lower tumbler is the next most important part. It is designed so that it revolves in bearings which are always submerged in grease. Wedge-shaped rings about the bearings secure it against end play. The bearing faces for the bucket chain are made with large central holes to prevent, as far as possible, the lodging of boulders under the links. These faces and the flanges which keep the chain in place are lined with renewable plates of manganese steel.

In some forms of construction the stacker carries off all the spoil, while in others a sand pump takes up the finer material after the gold is extracted and empties it out on the spoils heap.

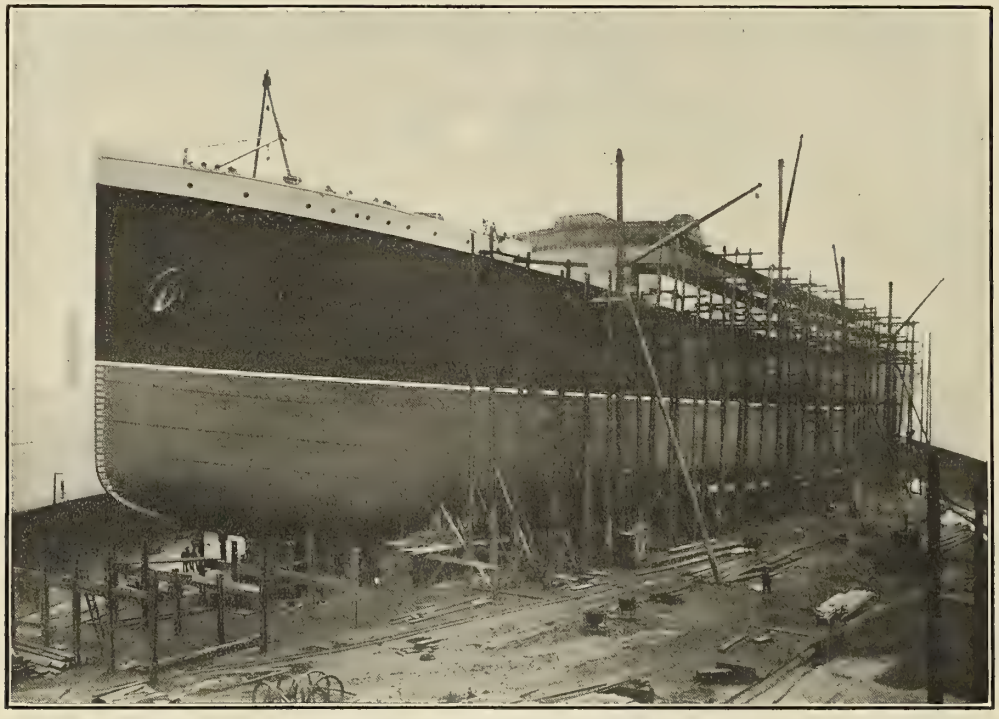
The company's new sand pump is novel in that when it is in operation it has a lining of clear water, which effectually prevents the sand held in suspension from cutting the pump. This lining is secured by having the water injected constantly from recesses in the hollow casing, as is shown in Fig. 6. In the long sluice dredge the action of the sand pump serves to thoroughly scour the gold particles and free them from any clay, leaving them bright and ready for amalgamation.

It is strongly recommended that all gold dredges be operated by electricity, even if a steam plant has to be set up ashore for the production of power. There are many good reasons for this recommendation. It saves valuable room on the dredge, where it is useful for gold-saving devices, and decreases the load carried. It also simplifies the question of supplying fuel. The great Oroville district in California has demonstrated the advantages of electric power for this work. Power is supplied there by the Valley Counties Power Company. It is a 3-phase alternating current of 4,000 to 5,000 volts, operating induction motors. The current costs 1½ cents per kilowatt hour.

Oroville is the greatest gold-dredge district now being worked. there being about thirty dredges in operation in the district. Other districts where gold dredging is being conducted successfully are Yuba River, Bear River, American River, Calaveras River, Sacramento River, Clear Creek, Trinity River, and Scott River, in California; Foot's Creek, Oregon; Goldfield District, Nevada; Bannock, Montana; McNutt and Brese Basin, Idaho; Elizabethtown, New Mexico; Fraser River, Atlin District, the Upper Yukon, Klondike River, Forty Mile River, British Columbia; Dutch Guiana, and other fields in South America and in New Zealand.

THE LAUNCH OF THE EMPRESS OF BRITAIN.

It is twenty-seven years since the Canadian Pacific Railway was begun. It is twenty years since the last spike was driven into the iron chain which connects the Atlantic and Pacific shores of the Dominion of Canada. At that time it was predicted that the C. P. R. would never earn enough money to pay for the oil to grease its engines, but regardless of prophets of evil it went into ship owning, and established the famous "Empress" line of steamers from Vancouver to the East to feed its railroad. These steamers were designed and built by the Fairfield Shipbuilding and Engineering Company, Glasgow, so when the C. P. R. decided to extend its feeders across the Atlantic, as well as across the Pacific, it was natural that it should turn once more to the Clyde. Moreover, it was at the Fairfield yard that the first of the breed of modern "Atlantic greyhounds" was born. And thus from this famous yard has just been launched one of the most notable additions to the fleets of floating palaces that now do business on the great waters of the North Atlantic. It is a newcomer in the traffic between Britain and Canada, which has so long been in the hands of a very limited number of British lines, but the trade is broadening and there should be room for all.



THE EMPRESS OF BRITAIN ON THE WAYS.

(Photograph, Allan McPherson.)

The twin screw steamer *Empress of Britain,* which the Fairfield Company launched, November 11, 1905, is the first of two sister ships they are building for the Atlantic mail and passenger service of the Canadian Pacific. The second, the *Empress of Ireland,* is well forward, and will be launched in January, 1906. The *Empress of Britain* is not the longest vessel which has been built by the Fairfield Company, but she is the heaviest. Their longest were the Cunard liners *Campania* and *Lucania,* launched in 1893, which are 601 feet in length, while the Canadian Pacific boats are 569 feet. The Cunarders are narrower, being 65 feet 2 inches compared with 65 feet 6 inches, and also less deep—37 feet 8 inches as compared with 40 feet to upper deck. The Canadian Pacific boats are of 14,500 tons gross, while the Cunarders are 12,952 tons. The *Empress of Britain,* which displaces 20,000 tons, is built to Lloyd's three deck and shelter deck 100 A1 class, with forecastle and long bridge. A cellular, double bottom is fitted the full length of the ship, and the vessel is subdivided into separate compartments by watertight bulkheads, which are constructed to obtain every security. There are nine watertight bulkheads, all extending to the level of the upper deck, built in accordance with the recommendations of the bulkhead committee. With any two compartments filled with water the ship would still remain afloat. All the decks are plated and sheathed, with teak where exposed, and with yellow pine where under cover. There are in all eight decks. On the boat deck at the fore end there is a spacious deckhouse for the accommodation of the captain and officers, with chart house and wheel house. In front of the wheel house, for the full width of the ship, is a space reserved for the navigation of the ship, and aft of the wheel house, divided from the officers' quarters by a barrier rail, is a fireman's airing space, with shelter in case of bad weather, and in direct communication with the boiler rooms.

In working out the design of this ship full consideration has been given to the experience of latest vessels built for the Atlantic trade in order that the new vessels shall embody everything that can be conceived for the safety and comfort of the traveling public. The design is by Dr. Elgar, the company's naval architect, and the building of the vessels has been under the direction of Mr. Arthur Piers, the manager of the Canadian Pacific's steamship department, assisted by Captain Mowatt, their marine superintendent at Liverpool.

Special consideration has been given to ventilation, and a thermotank system on the Stewart principle has been adopted as the most efficient method. There are 48 thermotanks placed to supply either heated or cold air, and to extract foul air from every corner of the ship, and they can be worked either separately or collectively so that any temperature can be maintained. Electric fans are also fitted in the public rooms and galleys. The sanitary arrangements have also received careful consideration, and a large number of lavatories, bath rooms, wash basins, etc., complete with hot and cold water and foot baths, are arranged at intervals on the various decks. The floors are laid with interlocking rubber tiles. There is a complete installation of electric light with three independent generating engines and dynamos, providing power for lights in all compartments. There are also a hospital, printing room, dispensary, hairdresser's shops, mail

rooms, and specie room, and wireless telegraphy with a suitable house fitted out for the receipt and dispatch of messages.

There are twelve cargo winches and two boat hoisting winches, and the driving gear is so arranged that no noise or vibration is created when working the cargo. The refrigerating installation is of adequate proportions for the preservation of general provisions, meat, vegetables, etc., and the making of ice. There are three large and one small refrigerating machines. The three large machines are for cooling the three large cargo cold chambers, the insulation and brine grids being so arranged that the temperature may be varied to suit the carriage of frozen meats, apples, etc. The small machine is for cooling the provision chambers on the upper deck, and the cold larder in the main galley. It can also make thirty blocks of ice, each weighing 18 pounds, in eight hours.

The steering gear is of the latest type, with telemotor, and there is also a reserve steam steering gear which may be readily put into operation if required. The gear is placed right aft on the orlop deck in a watertight compartment below the level of the waterline, and is coupled direct to the rudder post. It is actuated from the wheel house and also from the promenade deck aft. There is an indicator and a rudder tell-tale in the wheel house.

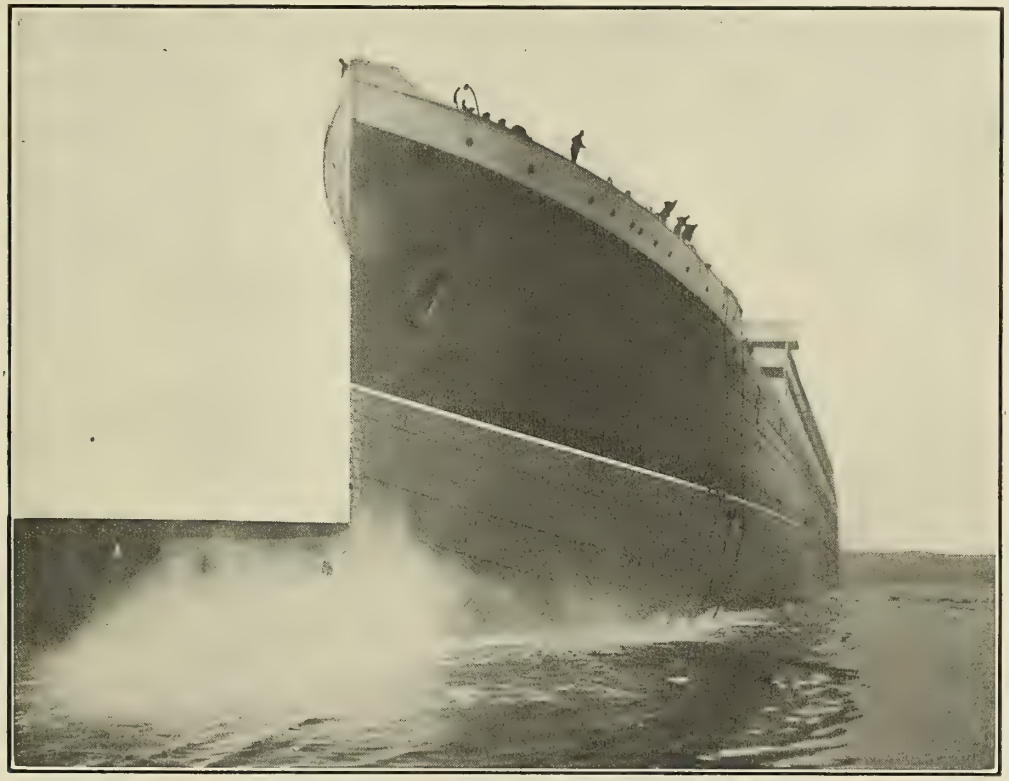
A powerful windlass of the direct-acting type is placed on the shelter deck, and a capstan driven off the windlass is fitted on the forecastle deck above. Two warping capstans at the aft end of the shelter deck are driven by horizontal steam engines, with slow and quick speeds.

A topgallant forecastle towers at a great height above the waterline, and will increase to a very large extent the weather qualities of the vessel. The forecastle on the upper deck is for the third-class passengers, that on the shelter deck for the crew.

The machinery consists of two sets of quadruple expansion engines, each with four cylinders working on four cranks, balanced on the Yarrow and Schlick system to reduce vibration to a minimum. The high-pressure and the first intermediate-pressure cylinders are fitted with piston valves, and the second intermediate and low-pressure cylinders with ordinary flat slide valves; and all are worked by link motion valve gear. The reversing gear is of the "all-round" type, controlled by a double cylinder steam engine. The crank shafts are in four sections, each section being built up, and like the thrust, tunnel, and propeller shafts, are of forged mild steel. The propellers have each four blades of manganese bronze, with bosses of cast steel.

Water is circulated through the condensers by two large centrifugal pumps, each worked by an independent engine. Both circulating pumps are connected to large valves leading to the bilges, and can be utilized for pumping out the engine room. The air pumps are independent of the main engines, being worked by separate steam engines. The engine room is fitted with two evaporators working in combination with two distillers for supplying fresh water to the ship and to the boilers, and with large feed filters, feed heaters and all necessary fittings to insure economy of working. A large installation of donkey pumps is provided for all requirements.

The boilers are nine in number, in two watertight compartments, with a large coal bunker between. There are six double-ended and three single-ended boilers of the ordinary multitubular type, arranged to work with Howden's forced draught. They are constructed entirely of steel and adapted for a working pressure of 220 pounds per square inch. The double-ended boilers have each eight furnaces, and the single-ended four furnaces—a total of 60. The products of combustion are led into two funnels.



TAKING THE WATER, SHOWING SMOKE FROM BURNING TALLOW.
(Photograph, Allan McPherson.)

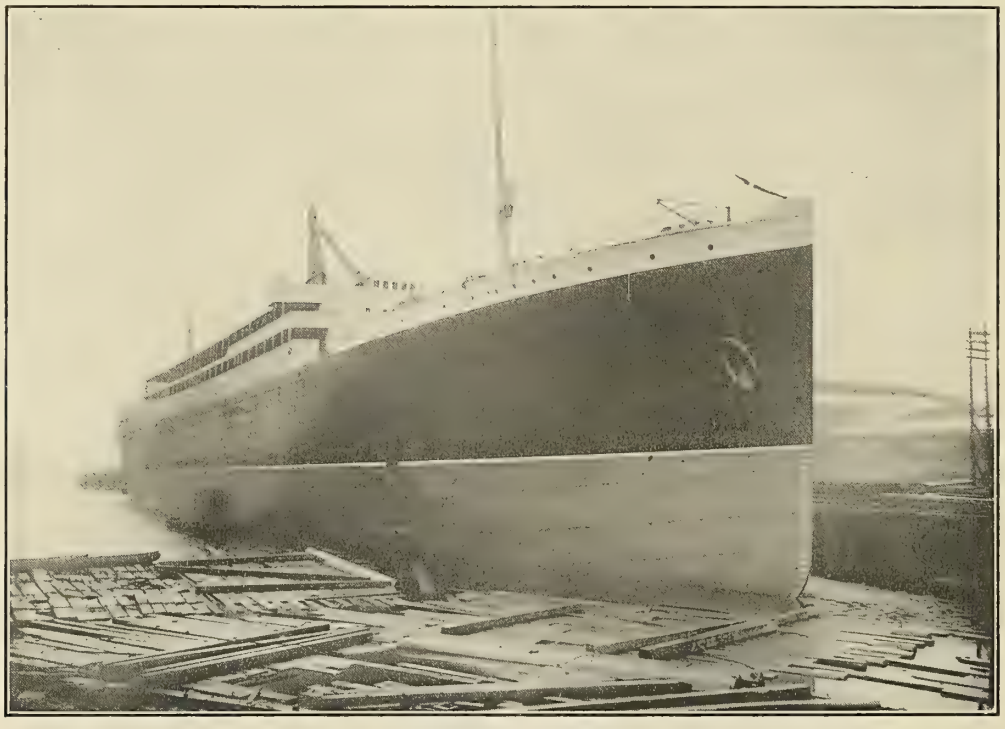
Accommodation has been provided for 310 first-class, 470 second-class and 500 third-class passengers, all on and above the main deck, and for 270 steerage passengers on the lower deck forward. The remainder of the lower deck, with the whole of the orlop deck and hold, is cargo space, and two of the 'tween deck holds will be insulated for carrying frozen meats.

The lower and upper promenade decks amidships are entirely devoted to the accommodation of first-saloon passengers. The staterooms for one, two or three persons are large, airy rooms with comfortable couches, combination double-folding washstands and writing tables, wardrobe with beveled pier glass, electric light, electric bells, and large, square opening windows with ornametal glass shutters. There are several family or

private cabins, built in pairs, with a door in the dividing bulkhead, so that any two of the rooms can be allotted to a party of two, four, or six persons.

On the upper promenade deck, amidships, the saloon entrance has a broad, handsome staircase leading to the lower promenade deck, and from there to the shelter deck. This staircase is paneled in light colored, polished teak, and lighted by a large dome. Abaft, on the upper promenade deck, is the music room, the ceiling and walls of which are of satinwood, with crossed bands of tulip wood. The library is a comfortable room, framed in mahogany with amboyna panels, with bookcase and other furniture to match. The café is immediately below the music room, and within easy reach of the first-class dining saloon. The paneling is framed in Italian walnut, waxed, with tapestry panels, and the floor is laid with rubber tiles. Aft of the café is a commodious smoking room, with large, square windows round the side, and a rectangular well over with ornamental fret, and provision for ventilation. The floor is laid with rubber tiles, and the walls are framed in slightly fumed oak with hammered copper panels. A clear promenade of 10 feet 6 inches wide for the kitchen, equipped with the best cooking apparatus, electric hoists and ventilating apparatus.

The second-class accommodation is on the shelter deck, dining saloon, social hall, and smoking room, with stairways leading to the upper and main decks. The dining saloon is capable of seating about 300 persons, and is fitted with alcoves at the side, like the first-class saloon. The walls are paneled in mahogany, with furniture to match. The social hall, or music room, is framed in light oak with light oak panels below and bird's-eye maple panels above. The second promenade deck is sheltered by the lower promenade deck, and on it the second-class smoking room is arranged with cosy corners and armchairs. The upper deck has two side fore and aft passageways, the one on the port side being for the ship's company, ship's provisions, butcher's shop, etc., and the working of the ship generally, and that on the starboard side is for first- and second-class passengers. A nursery is also provided for children. The majority of the second-class staterooms are on the main deck aft, and are airy rooms for two, three or four persons, fitted up somewhat similar to the first-class staterooms.



THE NEW SHIP ALONGSIDE DOCK FOR FITTING OUT.
(Photograph, Allan McPherson.)

first-class passengers, with recesses in the deckhouse forming sheltered corners, is on each side of the upper and lower promenade decks amidships. The lower promenade deck extends right aft to the stern of the ship, which is a new feature, and forms a fine open promenade for both first- and second-class passengers.

The first-class dining saloon is a splendid apartment, measuring 58 feet by 62 feet wide, and can dine the whole complement of saloon passengers at one sitting. In the center are four large dining tables running fore and aft, and at the sides, in alcoves, there is an arrangement of dining tables, each for five persons, the five seats forming a semi-circle round the tables. In each alcove are two large windows with ornamental shutters, which, together with a large oval dome overhead, afford light to the saloon. The paneling is in mahogany enameled white, with carving in old gold, and the furniture is upholstered in crimson leather. At the fore end is an upright grand piano and at the after end a large sideboard. The pantry is at the after end of the saloon, from which it is divided by a serving passage. This pantry, together with the pantry for second-class, and the various galleys, bakehouses, baker's shop, larders, etc., form one large

The third-class passengers are on the main deck forward in cabins accommodating from two to six persons, and there is a large dining saloon capable of dining over 300 persons. From stairways in each compartment the passengers can reach the promenade on the upper deck, which is covered, or the open promenade on the shelter deck. On the upper deck there is a smoking room and a ladies' room for the third-class.

At the forward part of the main deck and on the lower deck, provision is made for steerage passengers in open berths, with dining accommodation and other conveniences.

Civil Service examinations are announced for January 3 and 4, 1906, to fill vacancies in the position of local inspector of hulls of steam vessels, at $1,500 per annum. Age limit, twenty-five to fifty-five years. Applicants should apply to the Civil Service Commission, Washington, for forms 1,087 and 1,405.

Examination is announced for January 3 and 4 for vacancies in the position of assistant inspector for boilers and steam vessels, at $1,800 per annum. Age limit, twenty-five to fifty-five. Applicants should apply for forms 1,087 and 1,405.

MARINE APPLICATIONS OF THE CURTIS STEAM TURBINE.*

BY CHAS. G. CURTIS.

The first vessel to be propelled by steam turbines of this type, and the first vessel of any kind to be fitted with twin shafts and screws and twin turbines independently controllable and reversible, was the yacht *Revolution,* built in 1902. This yacht had a length of 140 feet on the waterline, beam of about 17 feet, a draught of 7 feet and a displacement of about 200 tons, and was provided with two independent turbines of about 1,200 horsepower each, turning outward and designed to run between 650 and 750 revolutions under full speed conditions. The turbine casing, including the reversing mechanism, was only 5 feet 10 inches in diameter and about 4 feet long. The turbines were not designed to show any remarkable economy, but were expected to consume about the same amount of steam as an ordinary triple expansion engine under the usual conditions of service. This yacht was put into commission in the spring of 1902, and was kept in commission and used for exhibition purposes continually, with the exception of two months during one winter, for a period of a year and a half.

The practical operation of the turbines was in every respect most satisfactory and convincing, neither one ever having required any repairs of any kind, and the steam consumption was shown by torsion shaft test to be substantially equivalent to that of the ordinary triple expansion engine under average working conditions. The boat, however, failed to develop the speed anticipated, and it was a long time before we could find out why this was so. The impression seems to have got abroad among marine engineers that the failure of this boat to show a speed consistent with the high power provided was in the main due to a failure of the turbines to develop the necessary horsepower. Such was not the fact. One of the turbines, when driving the screw in the ordinary way, was subjected to a very careful torsion shaft test by Prof. James E. Denton, who, with Prof. Webb, devised and worked out an ingenious and accurate method of measuring the angle of twist of a specially calibrated length of torsion shaft introduced into the line shaft for this purpose. The tests showed that the turbines developed the full power expected, and that the steam consumption was about 17½ pounds per indicated horsepower. The results are given in the following table:

POWER AND ECONOMY OF ONE TURBINE.

Number of Steam Passages in Use.	Revolutions per Minute.	Brake Horsepower or Horsepower Delivered to Propeller.	Indicated Horsepower of Equivalent Piston Engine.	Dry Steam per Hour Indicated Horsepower of Equivalent Piston Engine.
4	748.0	1,096.0	1,267.0	17.46
3	672.8	761.6	898.7	18.14
2	596.6	467.1	572.0	19.12
1	452.5	192.3	269.5	21.34
1 throttled.	265.3	95.7	146.2	24.67

The failure to get the expected speed, viz., 21 to 21½ knots, under conditions where the boat actually showed only about 18 knots, furnishes another illustration of how easy it is to "fall down" in an engineering matter of this kind, even when the best knowledge and talent are availed of. In order to insure success we not only had the vessel designed by a well known firm of yacht designers and builders who had previously built a yacht which was and still is the fastest yacht in this country, but we had the yacht's model tested in the government testing tank in Washington, and the screws were designed by a very distinguished authority in this country. Several sets of screws were built for the boat, the last set having a diameter of 4 feet and a pitch of 4 feet and having thin blades of well known form. From what is now known of the action of propellers of this character, and from the fact that the turbines did develop the power expected, we have been led to conclude that the trouble with the *Revolution* was in her model, which in the afterbody is very bad, her floor not being drawn out aft far enough. This view is confirmed by the best marine architects whom we have consulted about the matter and who have observed the wave action of the boat, which is very excessive, even at a speed of only 18 knots.

The reversing and maneuvering capacity of the *Revolution* was even better than anticipated, and was very satisfactory. In a maneuvering test made by a board of the Navy Department it was found that when going ahead at full speed (about 18 knots) the boat was brought to a standstill in the water in 32 seconds after the engine room telegraphs were thrown over. The boat was used extensively about New York harbor for a year and a half, and her reversing power was called into play to the utmost very frequently, but it never failed to respond with the necessary power, and during the whole period of her use as a "demonstration" no trouble of any kind whatever was had with either of the two turbines.

Some time ago the Fore River Shipbuilding Company, of Quincy, Massachusetts, at the instance of its president, Admiral Bowles, and after an investigation into the comparative merits of the two types of steam turbines available for the purpose, entered into contracts for the construction of two large vessels to be equipped with twin independent Curtis turbines, which vessels, together with the turbines, the company is now building. One of these is the United States scout cruiser *Salem* and the other is the Southern Pacific steamer *Creole,* particulars of which are as follows:

	Salem.	*Creole.*
L. W. L.	420 ft. 0 inches	415 ft. 8 inches
Breadth	46 " 8 "	53 " 0 "
Draught	16 " 9½ "	25 " 0 "
Displacement	3,750 tons	10,160 tons
Horsepower	16,000	8,000
Speed	24 knots	16 knots

In both vessels there are two shafts and two screws with complete independent turbines on each shaft. In the case of the *Salem* the proposed revolutions of the screw at 24 knots are 350; in the case of the *Creole* somewhere between 225 and 275. The space occupied by the turbines fore and aft (including the reversing mechanism) is only about half that occupied by the equivalent triple or quadruple expansion four-cylinder engine, and the weight is considerably less. In the case of the *Creole* the weight of the two turbines is, roughly speaking, about half of that of the equivalent quadruple expansion engine. The total saving in weight of the engines, shafting, propellers, etc., is very considerable. Each turbine is in the form of a drum-shaped shell, built up in sections, having an outside diameter of about 11 feet and an overall length of about 14 feet. Each turbine comprises 7 stages for going ahead and two stages for reversing. There is no end thrust due to the pressure of the steam in the turbine itself and the propeller thrust is taken up by the ordinary thrust block external to the turbine.

During the past summer the Vulcan Shipbuilding Company, of Germany, completed a turbine vessel called the *Kaiser,* which is fitted with two shafts and two independent turbines of this type. The turbines were built for the Vulcan Works by the Allgemeine Elektricitäts Gesellshaft, of Berlin, who are licensees under the Curtis Turbine patents, and were designed by and built under the direction of Mr. O. Lasche, the technical director of the turbine works of the Allgemeine Company. The performance of these turbines and of the vessel on her trial trip was admirable, and reflects great credit upon Mr. Lasche and his associates, and also the designing engineers of the Vulcan Works, who assumed the responsibility of getting efficient screw action under the unusual conditions. The guarantees were intended to represent the performance of a first class, 4-cylinder, triple expansion engine, and the ordinary slow-turning screws, which necessarily have a somewhat higher efficiency than the comparatively high-revolution

*Read at the thirteenth general meeting of the Society of Naval Architects and Marine Engineers, November 17, 1905.

screws requisite for turbine propulsion. The actual figures guaranteed were a speed of 19½ knots, and a consumption during a 6-hour run of not over 4,700 kgs. of coal per hour, including all auxiliaries. Progressive speed trials were had up to 20.46 knots, the propellers turning at 555 revolutions per minute. During a 6-hour run 20 knots was averaged on 4,060 kgs. of coal per hour. We have not yet ascertained positively what the horsepower developed was, but we understand that the shaft horsepower was measured by the use of a torsion shaft, and we understand on good authority that the indicated horsepower of the engines for the ship at 20 knots is estimated at 5,700. Whether this is derived from the shaft horsepower measurement or confirmed by the shaft horsepower measurement we do not as yet know. But if this figure—5,700 indicated horsepower—sent us is correct, the coal works out at 1.56 pounds per indicated horsepower, including all auxiliaries. The coal result is, if anything, better than these figures show, for during two hours the safety valves were blowing and the steam by-passing to the condensers. On a basis of the cube of the speeds the horsepower at 20 knots would be 8 percent greater than that at 19½ knots, and as the coal consumed at 20 knots was only 86.4 percent of that guaranteed for 19½ knots, it would appear that at a speed of 19½ knots the coal consumption would be just 80 percent of the amount guaranteed.

The dimensions of the vessel are as follows: Waterline length, 310 feet; beam, 38.2 feet; draught on trial trip, 9.74 feet; displacement, 1,890 tons of 2,240 pounds.

In order to test the maneuvering and backing qualities of the turbines, which were entirely independent, another engine-driven vessel belonging to the same line (the Hamburg Line) was brought to the spot for comparison, and it was found that the turbine ship was brought to a stop in the water in slightly less time than that occupied by the engine-driven ship. I am informed that during the trials the turbines gave no trouble, and their practical operation was entirely satisfactory.

Each turbine is built in the form of a drum-shaped shell built in sections, the shell having a length of about 11½ feet and an outside diameter of a little over 8½ feet, the reversing apparatus being all contained within the same shell. The weight allowed for each turbine was 70 tons, and the actual weight was 57 tons.

A very remarkable feature of the result seems to be the screw performance at the unusually high revolutions. Three or four pairs of screws were tried before the desired result was obtained, the turbines originally having been intended to run at 600 revolutions. The characteristics of the screw we have not as yet ascertained and cannot, therefore, state them, but it would seem from the excellent performance of the propelling machinery as a whole that the screws must have been surprisingly efficient in their action, considering the fineness of pitch involved.

Shop tests of the turbine to ascertain their horsepower economy had previously been conducted, the power developed being measured by a disk water brake with the following results: with a boiler pressure of 12 atmospheres or 190 pounds abs. with dry steam and a vacuum of 28 inches the steam consumption per brake horsepower was 12.76 pounds at 600 revolutions and about 13.7 pounds at 500 revolutions.

Iron- and Steel-Hull Steam Vessels of the United States is the title of a very interesting and historically valuable monograph by J. H. Morrison which has been running through the columns of the *Scientific American Supplement*. The series carries the development of the art from the early experimental period down to the present time, citing numerous notable examples of ships marking the different milestones of progress. A number of illustrations of the earlier constructions may be compared with those most up-to-date, and the great strides in the art readily followed. Among the ships noticed might be mentioned the old *Michigan*, now the *Wolverine*, which was the first iron warship constructed in any country. She was built at Pittsburg in 1842, and then shipped in sections to Lake Erie.

Winter Navigation of the St. Lawrence.

The Dominion government is about to test the feasibility of keeping the St. Lawrence river open to navigation during the winter months by the help of an ice breaker, such as has been successfully employed by the Russian government in the Baltic Sea. A conference has just been had between the Minister of Marine and the officers of the Dominion Coal Company, to whom the task has been assigned of sending, in December, from Sydney to Montreal, a coal-laden steamer, accompanied by the ice breaker *Champlain* from the vicinage of Quebec, where she is now waiting for the freezing of the river to make this trial. It is believed that there will be no difficulty in keeping the St. Lawrence open as far as Three Rivers at least, for a period in the early winter and spring, but much doubt is expressed regarding the part beyond here. The lake St. Peter, a few miles above here, *en route* to Montreal, will probably present the greatest obstacles, and it is doubted whether that portion of the river can ever be kept open. Should the experiments confirm this doubt the port of Three Rivers will naturally gain considerably in importance as a shipping center. The effort to escape from

ICEBREAKER MONTCALM, HAULED OUT FOR REPAIRS.

the present obligation of using Portland, Me., as port for the transatlantic shipping of this region of the Dominion is, of course a prominent factor in the ice-breaker project.—*Daily Consular Report*, December, 1904.

For the purpose of coping with the difficulties involved, there was launched from the yard of Messrs. Napier & Miller, Ltd., Yoker, the twin-screw ice breaker *Montcalm*, built for the Canadian government for work on the St. Lawrence, to the order of Messrs. Fleming & Ferguson, Ltd., Paisley, who have supplied the machinery. The principal dimensions are: length, 245 feet; breadth, 40 feet 6 inches; depth, 18 feet, with a gross tonnage of about 1,350 tons. The vessel has been built under Lloyd's special survey, and is designed for ice-breaking purposes, being greatly strengthened in order to resist the enormous pressure to which she will be subjected. The contract for this vessel was placed in July, 1904, and the building occupied a remarkably short space of time.

The *Montcalm* broke her propellers in ice ten feet thick, fifteen miles above Quebec, and was hauled out by Geo. T. Davie & Sons, Levis, Quebec, for repairs in weather "twenty below." The experiment is to be continued this winter, and better success is anticipated.

MOTOR BOATS, VII.

BY DR. W. F. DURAND.

ABOVE-WATER FORM.

The form of the boat above the waterline is to be determined by reference to the following four main considerations:

(1) Utility.
(2) Safety.
(3) Appearance.
(4) Air resistance.

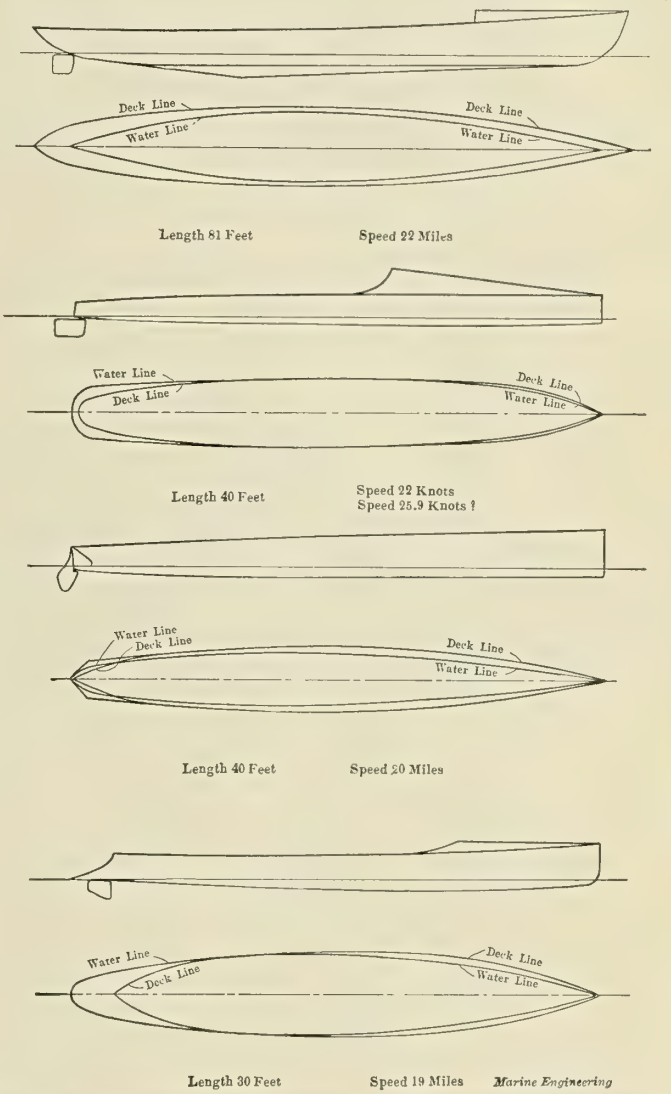
The relative importance of these will naturally vary with the details of the case in hand. Where the highest possible speeds are desired the question of air resistance will become of importance, and may lead to a type of form in which all other considerations are sacrificed in varying degrees. It will be convenient to take this extreme type of form as a starting point, and we shall therefore consider first the problem of air resistance and the means which may be taken in order to reduce to a minimum its influence on the speed of the boat.

Because air resistance is comparatively small, especially at low speeds, it should not be assumed that it is by any means negligible. Indeed when the highest attainable speeds are aimed at no item can be neglected, due attention to which might in any way help forward the main purpose in view. Air resistance becomes of the more importance because of the fact of cross and head winds which must be encountered, and the added relative velocity which will exist in the latter case. Thus a fast motor boat going at the rate of 20 miles per hour in still air meets an air resistance due to this speed. A moderate headwind of 10 to 15 miles per hour will raise the relative speed to 30 or 35 miles and will easily increase the air resistance to two or three times its first value. So much the more serious will be a headwind of 20 or 30 miles per hour, raising the relative velocity to 40 or 50 miles and increasing the air resistance four to six fold at the same speed through the water. With such a rapidly increasing fraction of the total power absorbed in overcoming air resistance, it is clear that any such conditions of adverse wind will seriously lower the highest attainable speeds, and that such scaling down will be more pronounced as the above-water form departs farther from the conditions for low air resistance.

As the first principle to be held in mind it may be stated that forms favorable with respect to air resistance should be as nearly as possible smooth and continuous in curvature, and especially with the minimum amount of abrupt change of form or flat head surface. Such features as a standing awning or a projecting pilot house should not be tolerated for a moment if air resistance is to be reduced to the lowest terms. In short, it should be remembered that the upper body of the boat is passing through a fluid (air) no less real than that through which the lower body is passing, and no less capable of occasioning a resistance, even though it is usually much less in amount. It follows that the form most suitable for low air resistance must be similar in general character to that most suitable for low water resistance; or, in other words, that the form of upper body should be not far different from that of lower body. This, of course, is impracticable in full measure, but we may with advantage remember that as the upper body is made to resemble the lower body in general form and character, so will the air resistance be decreased, and by so much less will the attainable speeds be cut down by this cause. It will thus be of interest to note the form of upper body which, in accord with these principles, would insure minimum air resistance.

Such a form would show in general a turtleback type of construction, covered completely over and sloping down to a junction with the under-water body as nearly as possible at the water surface. In side elevation it would show an arched form rising from near the water surface at the bow to a maximum height somewhat forward of amidships and sloping down gradually to the water surface at the stern. Similarly, in transverse section, the form will resemble an arch rising from the water surface at each side to a maximum height amidships, the general proportions of such arch being at the same time adjusted to the general character of the fore-and-aft form. Optical means for enabling the steersman to find his way, as well as general questions of light and ventilation, are, of course, matters which need not be considered in connection with such a form, which is intended only as an ideal toward which actual construction may approach as the need of reducing air resistance becomes of higher importance.

Habitability and general utility with such small boats require an open cockpit as well as some freeboard for safety, while for rough water conditions the forward deck cannot be made to



MOTOR BOATS, ILLUSTRATING TURTLE-BACK CONSTRUCTION, STRAIGHT SHEER LINES, AND VARIOUS FORMS OF STERN.

slope down quite to the smooth water line of flotation at the bow. It is of interest to note, however, that the turtleback form, especially forward, has met with favor by many designers, and that in skilled hands it may be treated in such manner as to yield a form not displeasing to the eye, and unquestionably contributing largely to the reduction of air resistance at high speeds.

Turning now to a more general census of the factors which determine the above-water form, they may be specified as follows:

(1) Sheer line and freeboard.
(2) Waterline.
(3) Form of bow.
(4) Form of stern.
(5) Arrangement of cockpit, deck erections, etc.

There is much diversity of practice in connection with the item of sheer. In general, however, the present fashion with motor boat designers seems to lead to less sheer than was formerly in vogue, especially for small craft of 20 feet or thereabouts in length. With racing craft, or boats of the highest attainable speed, the upper line shows often but slight sheer at the rail, and at a distance, taking the rise of the forward deck amidships, the central longitudinal line shows often a slope downward and forward, as in the turtleback type elsewhere referred to. Sheer has its uses in connection with safety and dryness forward, and unquestionably lends a jaunty and pleasing air to boats of moderate size, and with such other proportions and characteristics of form as show them to be intended for moderate speed. On the other hand, the long, slender form of the racer agrees well with the slightly curved rail line and with the forward and downward slope of the central fore-and-aft line, as noted above.

Freeboard as a factor in the above-water form bears important relations to both safety and air resistance, with perhaps more secondary relations to general utility and appearance. Insufficient freeboard may give rise to two dangers—the shipping of water in moderately rough weather and a reduced range of stability. Each of these may involve some element of danger for the boat, and having due regard to safety in these respects, a reasonable freeboard should be provided. What is reasonable in any given case must be determined by the designer in view of all circumstances of the case, and for the purposes of the present discussion it will be sufficient to simply note the principle that in general increase of freeboard up to some value considerably beyond the usual proportions will make for increased stability range, and for added safety in this particular. Increased freeboard means however, increased air resistance, especially in a headwind; and here, as at all other points, we meet the necessity of compromise and adjustment between mutually conflicting requirements.

Regarding the waterline or plan view, the form and proportions of this feature will depend primarily on the under-water body, as considered in the preceding chapter, and this item will require no further consideration at the present point.

Regarding the form of the bow, some designers are disposed to flare out the sections from the water surface upward at and near the bow, thus rapidly increasing the bearing as the bow descends into the water or dives into a wave. This will have the effect of reducing somewhat the extent of pitching in a head sea, and may thus contribute to safety and comfort. As a rule, however, having in view the average weather in which such boats are expected to be used, most designers are content with a nearly vertical side at and near the bow, depending on the freeboard and other general proportions to give the needful steadiness relative to pitching, and the general safety relative to the action of the waves.

The form of the cutwater has been noted in the preceding chapter. General practice leans toward a cutwater raking somewhat forward and with a rounded curve under the forefoot. The tendency of these characteristics in excess will be to shorten the waterline length when running at high speeds, as already noted. So far as this consideration is concerned, therefore, the forward rake should be very nearly suppressed and the round under the forefoot should be kept at least under water when at full speed.

Coming next to the stern, we meet perhaps the most difficult of all features of boat design, especially with reference to considerations of general appearance. The character of the torpedo-boat stern has been already referred to in connection with the discussion of the under-water body. There is no question of the difficulty of the problem which this stern has presented to designers with respect to the combination of the typical form below water with pleasing form characteristics above water. In the earliest sterns of this type the above-water form was usually some close approximation to the older and familiar round or raking stern, joined by an abrupt knuckle to the flat floor of the under-water body. These combinations were rarely graceful or pleasing, representing as they did the attempted combination of two entirely distinct types of form, neither part properly adapted to the other. In later and more satisfactory forms the old and conventional stern has been left aside and new above-water forms have been developed in conformity with the general conditions of boat design and with the type of under-water body with which they are to be joined. In certain varieties of this type the member corresponding most nearly to a sternpost is raked or curved forward, while the water-plane and horizontal sections cut by all parallel planes are brought to a point either sharp or somewhat rounded. The chief disadvantage of this variety is perhaps that in its more narrowly pointed extreme it is somewhat less well adapted to a wide and roomy stern cockpit, or in any event such pit cannot extend quite as far aft as in forms which are broadly rounded or flat across the after extremity. Such rounded or flat varieties, with more or less pronounced tumble home, and in elevation showing a forward rake to the after boundary line, represent still other solutions of the same general problem; and all varieties here noted, with intermediate gradations, are to be found in the practice of the day. Reference may also be made to the cuts accompanying the preceding and present chapters for illustrations of these forms of above-water body.

Comparing for a moment the torpedo-boat stern with the older or ship form with deadwood and fine waterlines aft, it will be seen that the natural widening of the above-water body which the torpedo-boat stern permits gives usually more width and roominess on about the same proportions, and is thus favorable to general utility and comfort. With the rounded or flattened after extremity this width is especially pronounced, and is the feature especially commending such variety of form for various classes of boats. Naturally, however, excessive width and roominess must go with moderate speed, and *vice versa* the highest speeds can be expected only with such forms as involve some sacrifice of width and general carrying capacity. Utility, further, is a quality which must be interpreted in accordance with the nature of the case, and it is not until it is thus interpreted and expressed in engineering terms that it becomes a matter capable of direct study and definite determination.

Again, as regards appearance, it must be remembered that this is largely a matter of taste and convention, and taste is largely a matter of education. When the torpedo-boat stern was first introduced it was generally considered as decidedly ugly and lacking in all those qualities of grace and beauty which may be embodied in the older and conventional form. To-day forms of torpedo-boat stern are worked out in such a manner as to appear pleasing to the eye and generally satisfying to our sense of the beautiful. This is due to two chief causes: (1) Since its first introduction we have become accustomed to the general characteristics of this form of stern and to its peculiarities, as distinguished from the older form, and have thus become educated in the toleration and acceptance of features which, with our conventions and ideas of fifteen years ago, seemed crude and displeasing. (2) The problem has received a vast deal of attention and study on the part of naval architects and designers. and forms and proportions have been evolved which are unquestionably more pleasing than those through which this form of stern first made its appearance as a factor in small boat design.

Again, it must be accepted as a principle of all such classes of design that in a boat intended for the highest speed, considerations of utility and especially of appearance must be made subordinate to those qualities having primary relation to the requirement of speed. It must not be concluded, however, that a fast boat is necessarily ugly. Within the limitations imposed by the requirement of high speed, the skilful designer will be able to combine his elements in such manner as to be at least not displeasing to the eye while at the same time fulfilling the technical requirements for maximum speed.

So far as considerations of safety are concerned, the torpedo-boat stern suffers somewhat by comparison with the older form as regards ease of riding through a seaway. The flat under-water after body may result in a tendency to pound in a choppy

sea, while backing into a strong head sea is of course well nigh out of the question. On the other hand, the increase in average beam at the waterline, which is a pronounced feature of the flat stern, makes for stiffness and large stability for small angles of heel, though the range of stability may be no more or even less than for the older form.

So far as air resistance is concerned there is but little to choose between the two fundamental types of stern, though of all varieties in actual use the typical form with forward rake and with sharp or moderately rounded after extremity will undoubtedly show most favorably in this respect.

Because the flat or torpedo-boat stern has been treated thus in detail it must not be considered that it is the only form of stern used for small craft of the motor boat class. The old and conventional stern with deadwood is still met with, and in particular for boats intended for cruising purposes, and where moderately heavy weather may be expected; or, on the other hand, in boats intended for very shallow water, or when the fullest measure of protection to the propeller is desired.

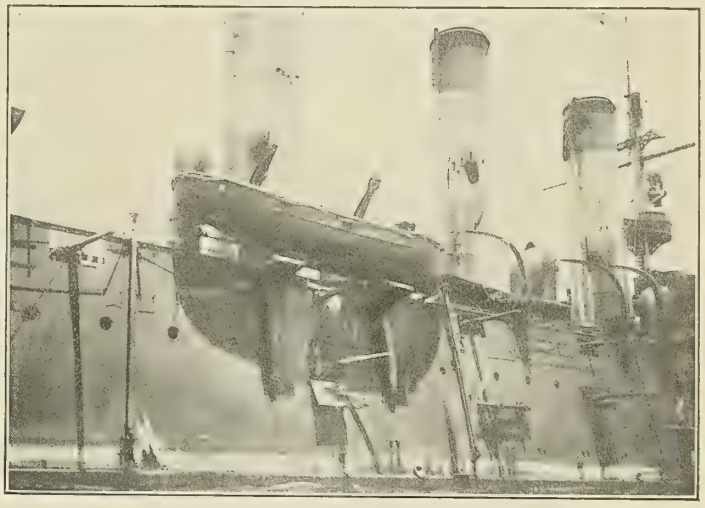
Again, there are various intermediate types coming under the head of compromise sterns, and intended to retain the favorable qualities of the flat stern with respect to resistance and propulsion and at the same time to avoid some measure of the uneasiness of the full flat stern when riding in heavy weather. Such forms have usually no deadwood and show an under-water body sloping upward toward the stern, but with sections somewhat rounded or eased off at the waterline, thus avoiding the full flat characteristic of the typical torpedo-boat stern. The above-water body may be worked out in various forms according as the design leans more nearly toward the old conventional form or toward the flat torpedo-boat model. There is probably little to be gained by the use of such compromise forms beyond some slight measure of better adaptation to rough water conditions. For smooth water, or such conditions of water and weather as may be fairly considered typical for the motor boat class, the flat or full torpedo-boat stern may be accepted as generally preferable from all points of view.

Regarding the item of cockpits, trunk cabins and deck erections of all kinds, little can be said of value in a general discussion such as the present. These features pertain chiefly to utility, and their character must be determined in connection with the special needs of the case. The influence of deck erections in augmenting air resistance has been already referred to, and for high speeds so serious will this become that with small boats these features of comfort and utility must be sacrificed if the highest attainable speeds are contemplated.

The general consideration of safety has been mentioned in connection with several features of the above-water form. Some further points may be noted as follows:

It is clear that the above-water form which is ideal for smooth water conditions will be far from permissible in rough water, or even in the average weather conditions with which such boats are expected to be able to safely contend. Especially will this be true for high speed requirements, and it follows that the above-water form as related to speed in particular, and all other requirements in general, must be determined with reference to average weather conditions. In particular, will such requirement lead to modification in the ideal turtleback form of forebody. In average weather conditions a forward deck sloping down nearly to the waterline at the bow, as determined by smooth water trim, would result in the boat's running most of the time with her nose under water, and in heavy weather such a form would be quite out of the question, at least for any speed above the very slowest. While, therefore, a turtleback form is favorable to reduced air resistance, and to the rapid shedding of a wave should it break over the bow, yet its height nevertheless must be such as to lift it above the reach of the ordinary small waves, and beyond the likelihood of nosing deeply into the water under such weather conditions as are liable to be encountered. The same considerations will lead to a general increase of freeboard over that suitable for smooth water, and to other modifications of minor character intended to render the boat safe and comfortable under average weather conditions.

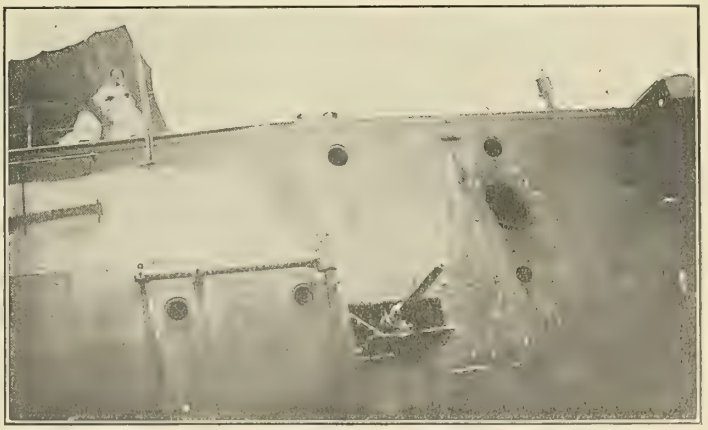
STARBOARD SIDE OF THE OLEG.



AURORA, SHOWING SHOT-HOLE OVER 3-INCH GUN.

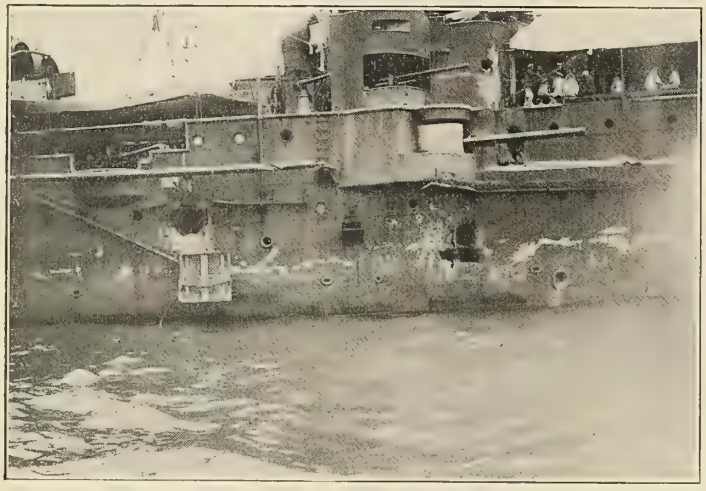
Russian Cruisers in Manila Bay.

The photographs reproduced here show some results of Japanese gunnery at the battle of the Sea of Japan. The two cruisers depicted are the *Aurora* and *Oleg*. One of the shot holes shown just above a 3-inch gun opening on the *Aurora* was made by a shell which exploded on impact, put the gun out of action, and killed every man in the gun crew. Most of the other hits were not so damaging, but it will be seen that the two ships, which, with the *Jemtchug*, were the only ones to reach Manila after the



STARBOARD BOW OF THE AURORA.

battle, did so only after having been subjected to a hot fire. We are indebted for the photographs to Mr. Francis J. French, who obtained them in Manila.



THE BATTERED SIDE OF THE OLEG.

Mr. French sent us at the same time a blue print showing a target which had been fired upon by one of the 13-inch guns of the United States battleship *Wisconsin* at a range of 1,600 yards, the ship meanwhile steaming past at a speed of ten knots. This target practice, which took place February 4, 1905, resulted in the placing of twelve shots through the bullseye within a period of five minutes forty seconds, or rather more than two bullseyes per minute. When it is remembered that the 13-inch guns used at the battle of Santiago in 1898 could be fired not oftener than about once in three minutes, the above record will be seen to be a striking example of the wonderful progress made in the United States Navy in gunnery during the past seven years, while of course the absolutely clean record of bullseyes is wholly without a rival.

Calculating the Size of the Cylinders for a Multiple Expansion Engine.

BY GEORGE ELFERS.

As is well known, one of the greatest heat wastes of the steam engine is that of cylinder condensation, due to the alternate heating action of entering steam and cooling effect of expansion and condensation. This loss is reduced by steam jacketing the cylinders, superheating the steam, high compression of the exhaust steam in the clearance space and by the very common method of using two or more cylinders in series. The use of the multiple cylinder engine, in which the steam exhausted from one cylinder is used again in a succeeding one, is by far the best method of reducing the losses through cylinder condensation; and at the same time allows the use of higher ratios of expansion, resulting in an increase in the thermodynamic efficiency of the engine.

The first step in designing any engine is to determine the best ratio of expansion, for that type of engine, under the assumed conditions of operation. In one case, for instance, it might be necessary to sacrifice efficiency of the engine in order to come within the allowable limit of weight, in which case a low ratio of expansion would have to be used; then again in another case where an engine is wanted for long voyages efficiency would be paramount and a high ratio of expansion would be necessary. The total ratio of expansion varies with the steam pressure and the total number of cylinders in series. The present practice is about as follows:

Number of cylinders..	1	2	3	4
Steam pressure, in lbs..	Up to 100	90 to 150	150 to 250	200 and up
Ratio of expansion....	1.5 to 3	4 to 6	7 to 12	11 to 15

In laying out the cylinders for any multiple expansion engine it is essential that they be so proportioned as to develop about the same power in each; with this arrangement all parts of each engine undergo the same amount of wear and are under the same stress. For the purpose of illustrating the manner of solving this problem let it be assumed that we wish to calculate the diameters of the cylinders of a triple expansion engine of about 2,400 indicated horsepower; the boiler pressure being given as 200 pounds by gauge or 215 (nearly) absolute. There is always a drop in the pressure between the engine and boiler of about 10 pounds, so that the pressure of the steam at the engine, in this case, would be 205 pounds absolute.

The well known formula for horsepower is

$$I.H.P. = \frac{2 \times p_m \times L \times A \times N}{33{,}000} = \frac{p_m A\,(2LN)}{33{,}000} \quad \ldots\ldots (1)$$

in which,

$I.H.P$ = Indicated horsepower.
p_m = Mean effective pressure.
L = Length of stroke.
N = Number of revolutions per minute.
A = Area of piston in square inches.
$2LN$ = Piston speed in feet per minute.

The value of p_m, the mean effective pressure, which we may expect to get depends upon:

(1) The initial steam pressure. The higher the initial steam pressure, the higher will be the value of p_m, other things being equal.

(2) The thermodynamic efficiency designed for. The thermodynamic efficiency of any steam engine may be expressed by the equation

$$T = \frac{t_1 - t_2}{t_1 + 4},$$

where T = thermodynamic efficiency,
t_1 = the temperature of the steam at admission,
t_2 = the temperature of the steam at exhaust.

In order to lower the value of t_2 and thereby increase the efficiency, the steam must be expanded as many times as possible under the conditions of operation. The ratio of expansion can be carried too far for economy, though this is not likely to occur within the allowable limits in the diameters of low pressure cylinders and weight of engines that can be used in marine work.

(3) The weight of engine required. As the ratio of expansion increases the mean effective pressure decreases, and hence the area of the low-pressure cylinder increases, and with it the weight of engine.

For purpose of illustration, assume that a ratio of expansion of 11 has been decided upon. This is a fair value for a triple-expansion engine using steam at a pressure of about 200 pounds.

As the steam expands in the cylinder, the pressure varies inversely as the volume, and the theoretical expansion curve is a hyperbola. The mean length of the ordinates to this curve can readily be found from the equation:

$$p_m = p_1 \frac{(1 + hyp.\,log.\,r)}{r} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

in which equation p_m = mean pressure,
r = ratio of expansion.
p_1 = initial pressure.
$hyp.\,log.\,r$ = hyperbolical logarithm of r.

As this equation stands it does not take into account the losses due to expansion in the receivers, wire drawing in the ports, compression, radiation, friction of the steam in passing through the ports, etc. These losses are represented by what is known as the card factor, which is equal to the ratio of the theoretical mean pressure to the actual pressure. Its value is determined from indicator cards taken from actual engines. For a triple expansion engine the card factor varies from .65 to .75, and for a quadruple from .55 to .65.

Putting the card factor equal to f, and the back pressure as p_b,

formula (2) can be rewritten

$$p_m = f\left[p_1 \frac{(1 + hyp.\ log.\ r)}{r} - p_b\right] \ldots\ldots\ldots (3)$$

Now by substituting for f, p_1 and r their values as assumed above and finding, from any handbook on engineering, the value of the hyperbolical logarithm of 11, the ratio of expansion as assumed, and allowing a back pressure p_b in the condenser of 3 pounds absolute, the value of p_m, the mean effective pressure, becomes

$$p_m = .66\left[205 \frac{(1 + .2397)}{11} - 3\right] = 39.8$$

Now in formula (1) $2LN$ is the piston speed. This varies with the type of engine from about 500 feet per minute in slow-running freighters to about 1,200 in high-speed engines of the torpedo boat type. The piston speed must be assumed before the dimensions of the cylinders can be found. In this case assume a piston speed of 700 feet per minute.

In a multiple-expansion engine we may consider the steam as if expanded in a single cylinder of the same size as the low pressure. Writing formula (1) in terms of A, the area of the low pressure cylinder, we have

$$A = \frac{I.H.P. \times 33{,}000}{p_m\,(2LN)} = \frac{2{,}400 \times 33{,}000}{39.8 \times 700} = 2{,}842 \text{ square inches,}$$

equivalent diameter, 60⅛ inches.

This is the area of the low-pressure cylinder required for an engine of 2,400 indicated horsepower, running under the conditions assumed above. If the piston speed had been assumed as 750 feet per minute then the area would have come out as 2,653 square inches, or about 58¼ inches diameter.

Thus far not a word has been said about the high-pressure cylinder, to find the diameter of which it is necessary to determine the ratio of the high-pressure to that of the low-pressure. To this end it is necessary to decide upon the point of cut off in the high-pressure cylinder, and also to assume the amount of clearance this cylinder will have when actually made. In this case assume the cut off at 65 percent of the stroke, and the clearance volume as 12 percent of the cylinder volume. Then there will be $\frac{1 + .12}{.65 + .12} = 1.455$ expansions in the high-pressure cylinder. Hence, it is easily seen that the ratio of the area of the high-pressure cylinder to that of the low-pressure must be equal to the total ratio of expansion divided by the number of expansions that take place in the high-pressure cylinder, and in this case the ratios of the areas would be $11 \div 1.455 = 7.56$. The area of the low-pressure cylinder being 2,842 square inches, as found above, then the area of the high-pressure is

$$\frac{2{,}842}{7.56} = 376 \text{ square inches, or about 22 inches diameter.}$$

The area of the intermediate cylinder is made a mean proportional between the area of the high-pressure and that of the low-pressure. Hence, dividing the area of the low-pressure by the square root of the ratio of the areas of these two cylinders, in this case 7.56, the area of the intermediate-pressure cylinder is

$$\frac{2{,}842}{\sqrt{7.56}} = 1{,}033 \text{ square inches, or } 36\tfrac{1}{4} \text{ inches diameter.}$$

For different values of piston speed there will be corresponding values for the diameters of the three cylinders. Thus, any of the combinations below will give an engine of about 2,400 indicated horsepower, under the conditions of operation as assumed at the outset.

Dia. H. P.	Dia. I. P.	Dia. L. P.	Piston speed, feet per min.
22 inches	36¼ inches	60⅛ inches	700
21⅛ "	35⅛ "	58¼ "	750
20½ "	34⅛ "	56¼ "	800
19⅞ "	33 "	54⅝ "	850

The next step is to determine the stroke of the engine, which is usually about one-half of the diameter of the low-pressure cylinder, or very nearly so. Thus, in any of the above cases the stroke could be anywhere between 27 inches and 33 inches and not be out of usual proportions. As soon as the stroke has been determined, the revolutions at which the engine must run to develop the designed power can readily be found by dividing the piston speed by twice the length of stroke, in feet.

To lay out the cylinders for a quadruple expansion engine the same method of procedure is available. To illustrate, suppose that the same problem is to be solved for a quadruple engine. In this case assume a card factor of .55 and a ratio of expansion of 14. The value of p_m can then be found from the same formula as used above.

$$p_m = .55\left[205 \frac{(1 + .2639)}{14} - 3\right] = 27.66 \text{ pounds.}$$

If the engine is to run at a piston speed of about 800 feet per minute, the area of the low-pressure cylinder must be equal to

$$A = \frac{33{,}000\ I.H.P.}{(2 \times L \times N)\ p_m} = \frac{33{,}000 \times 2{,}400}{800 \times 27.66} = 3{,}580.$$

If we consider the point of cut off and the clearance of the high-pressure cylinder to be the same as in the above case, then the number of expansions of steam in the high-pressure will be the same, 1.455, and since there are to be 14 expansions in all, the ratio of the area of the low-pressure to that of the high-pressure will be $\frac{14}{1.455} = 9.62$

Now let A_1 A_2 A_3 be equal to the areas of the high-pressure, first intermediate-pressure and second intermediate-pressure, respectively. Then from above

$$A_1 = \frac{3{,}580}{9.62} = 372 \text{ square inches.}$$

Now $A_1 : A_2 = A_3 :$ Area of low-pressure or $A_1 : A_2 = 1 : \sqrt[3]{9.62}$

Hence $A_2 = \sqrt[3]{9.62} \times A_1 = 2.13 \times 372 = 792$ square inches.

Also $A_2 : A_3 = 1 : \sqrt[3]{9.62}$

$A_3 = \sqrt[3]{9.62} \times A_2 = 2.13 \times 792 = 1{,}686$ square inches.

which is equal to the area of the second intermediate-pressure cylinder.

Thus, we have the areas of the four cylinders when the piston speed is assumed to be 800 feet per minute. For any other piston speed an entirely new set of values for the areas of the cylinders will be found when solved as above. Having found the required areas of the several cylinders it is an easy matter to solve for the diameter. The quadruple expansion engine will be heavier than the triple, but the coal consumption of the latter will be somewhat the greater.

Oil Fuel for War Ships.—A British Admiralty committee has evolved a burner for oil fuel on board ship, and practically all the British warships now building will be so fitted that oil may be used as an alternative to coal. The various contractors are pledged not to divulge the details of the burner, upon which depends the economy of the system. Oil fuel will not be continuously used in the British naval service, but ships in commission will use it often enough to insure that the system is kept in satisfactory condition, and the staff experienced in its application. The chief advantage claimed for oil fuel is its high evaporative power. Under the best theoretical conditions each pound of oil should generate 20 pounds of steam, from and at 212 degrees Fahrenheit, but this is never realized in practice. The elaborate tests conducted by the United States Navy Department indicated that in ordinary service each pound of oil would generate from 12 to 13 pounds of steam, from and at 212 degrees Fahrenheit. This is about 40 percent more than can be got from the best Welsh coal, but in the British service better efficiency is obtained with the new burners. One of the best results was

achieved in some tests made by Professor Watkinson, of Glasgow, with a system worked out in Glasgow by the Lucal Light and Heating Company. Under normal conditions, 16 pounds of steam were generated per pound of oil and the amount of steam used for the atomizing and vaporizing of the oil was only 1½ percent of that generated, as compared with 4½ percent in the United States navy tests. Oil fuel need not affect the boilers if the necessary safeguards are taken. In many merchant ships using the system the back and sides of the combustion chamber are protected with brick work carried up above the level of the crown of the furnace, while the furnace also is bricked, and brick baffles are fitted to break up the torch-shaped flame within the furnace itself. The oil in warships will be carried in the double bottom, the usual coal bunkers being retained alongside the machinery and boiler spaces.

SHIPBUILDING IN THE UNITED STATES IN 1905.

Through the courtesy of the Bureau of Navigation, we are enabled to present figures covering the shipbuilding operations in this country during the past year. These figures are exact up to the end of November, while the computation is carried on to December 31, by means of an estimate based on the December tonnage of previous years as compared with the eleven months of the year prior to December. This information is given in four tables, the first of which shows the total of all mercantile vessels built in the United States (aside from unrigged barges) for the calendar years 1900 to 1905 inclusive, and shows that the high-water mark was reached in 1902, with 434,000 tons of shipping. It will be noticed from this table that the average size of ships included is very small, in no case exceeding for any year 350 tons. This is due to the fact, of course, that there

VESSELS BUILT IN THE UNITED STATES.

Year.	Ships.	Gross Tons.	Average Tons.	Great Lakes Ships.	
				Gross Tons.	Percent.
1900	1,102	365,791	332	129,973	35.6
1901	1 322	376,129	284	156,157	41.5
1902	1,270	434,005	342	158 230	36.5
1903	1,159	381,970	330	182,593	47.8
1904	1,063	265,104	249	54,042	20.4
1905	1,036	311,611	300	189,981	61

are included in the figures vessels of all sizes down to the smallest, many of which are of very small value so far as shipping as a whole is concerned. Another column of this table shows the tonnage constructed on the Great Lakes in these several years, and the percentage of this tonnage to the total is also given. It will be seen that this percentage, which averaged about forty during the first four years of the period, exceeded sixty in 1905.

Taking the most important class of ships constructed, namely, steel vessels propelled by steam, we show in another table figures for each six months for the same period of six years, the figures

STEAM STEEL VESSELS BUILT IN THE UNITED STATES.

Six Months, Ending	Totals.		Atlantic and Gulf.		Great Lakes.	
	Ships.	Gross Tons.	Ships.	Gross Tons.	Ships.	Gross Tons.
June 30, 1900	52	105,713	31	34,803	17	63,885
Dec. 31, 1900	40	91,244	20	44,179	16	44,626
June 30, 1901	64	144 021	31	46,297	30	91,994
Dec. 31, 1901	40	74,604	21	25,541	17	49,020
June 30, 1902	74	196,197	34	76,186	32	109,019
Dec. 31, 1902	42	98,516	26	52,385	12	43,248
June 30, 1903	69	153,389	33	54,411	29	88,412
Dec. 31, 1903	50	126,392	20	36,077	28	89,562
June 30, 1904	43	113,261	27	61,904	13	50,336
Dec. 31, 1904	31	19,472	25	16,955	5	2,498
June 30, 1905	42	139,883	17	39,822	24	99,999
Dec. 31, 1905	47	104 925	22	18,309	23	86 302

for December being estimated as before. These figures show the continuous reduction in tonnage on the Atlantic and Gulf during the past two or three years, while it is further shown that the tonnage on the Great Lakes in 1905 was greater than in any previous year. These tonnages by years are further shown graphically in the chart presented herewith, which gives an idea as to the gradual decadence on the Atlantic coast and the general increase with the exception of one year on the Great Lakes.

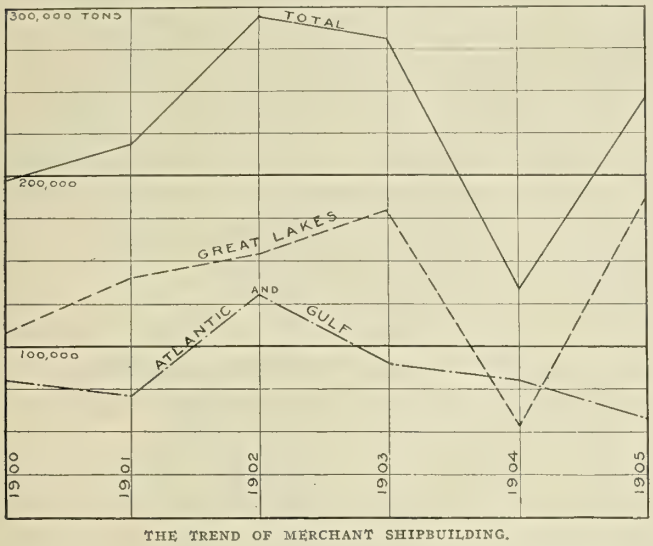
SEABOARD. Steel Steamers.	Tons	Built.	Owner or Builder.
Dakota	20,714	New London, Conn.	Great Northern S.S. Co.
Providence	4,365	Quincy, Mass.	Old Colony Steamboat Co.
Chippewa	2,696	Philadelphia, Pa.	Clyde S. S. Co.
Onondaga	2.696	Philadelphia, Pa.	Clyde S. S. Co.
Manhattan	2,006	Sparrows Point, Md.	New York City.
Brooklyn	2,006	Sparrows Point, Md.	New York City.
Bronx	2 006	Sparrows Point, Md.	New York City.
Queens	2.006	Sparrows Point, Md.	New York City.
Richmond	2,006	Port Richmond, N. Y.	New York City.
Elmira	1,460	Newport News, Va.	D. L. & W. R. R. Co.
Goshen	1,459	Wilmington, Del.	Erie Land & Improvem't Co.
Car Float No. 2	1,374	San Francisco, Cal.	So. Pac. R. R. Co.
San Francisco (wood).	1,070	Alameda, Cal	S. F., O. & S. J. R. R. Co.
(Thirteen)	45,864	Average, 3.528 tons.	
GREAT LAKES. Steel Steamers.			
William G. Mather.	6,838	Ecorse, Mich.	Cleveland Cliffs Iron Co.
James C. Wallace	6,684	Lorain, O.	American Shipbuilding Co.
Joseph G. Butler, Jr.	6,588	Lorain, O.	American Shipbuilding Co.
William A. Rogers.	6 524	Lorain, O.	American Shipbuilding Co.
Henry C. Frick	6,490	West Bay City, Mich.	Pittsburg S. S. Co.
George W. Perkins	6,466	Superior, Wis	Superior Shipbuilding Co.
William E. Corey	6,363	Chicago, Ill	Pittsburg S. S. Co.
Leonard C. Hanna.	6,356	Cleveland, O.	American Shipbuilding Co.
Elbert H. Gary	6.331	Chicago, Ill	American Shipbuilding Co.
Amasa Stone	6,282	Wyandotte, Mich.	Mesaba S. S. Co.
Socapa	6,272	West Bay City, Mich.	Superior S. S. Co.
Sylvania	6,272	West Bay City, Mich.	W. Bay City Shipbuilding Co.
James E. Davidson	6,206	Ecorse, Mich.	Great Lakes Engin'g Works.
Lyman C. Smith	6,200	Wyandotte, Mich.	Lyman C. Smith Transit Co.
Peter White	6.184	Ecorse, Mich.	Presque Isle Transport'n Co.
Powell Stackhouse	6,171	Wyandotte, Mich.	Mahoning S. S. Co.
John Stanton	6 129	Lorain, O.	American Shipbuilding Co.
Philip Minch	5 865	Lorain, O.	American Shipbuilding Co.
Hoover & Mason	5.841	Ecorse, Mich.	Great Lakes Engin'g Works.
Stephen M. Clement	5,821	Lorain, O.	Buf. & Susquehanna S. S. Co.
William A. Paine	5.798	Cleveland, O.	Pioneer S. S. Co.
Ball Brothers	5,731	Lorain, O.	American Shipbuilding Co.
James P. Walsh	5,630	Toledo, O	Craig Shipbuilding Co.
George H. Russell	4 978	St. Clair, Mich.	St. Clair Engineering Works.
Frank J. Hecker	4,978	St. Clair, Mich.	St. Clair Engineering Works.
Superior	4 544	Ecorse, Mich.	Western Transit Co.
Juniata.	4.333	Cleveland, O	American Shipbuilding Co.
Francis L. Robbins.	4.222	Cleveland, O	American Shipbuilding Co.
Delaware	3.901	Ecorse, Mich.	Erie & West. Transp n Co.
Marquette & Bessemer No. 2	2,514	Cleveland, O.	American Shipbuilding Co.
(Thirty)	171,018	Average, 5,701 tons.	

The third table covers the construction of steel steamers of over 1,000 tons each during the year. It will be noted that thirteen of these steamers only are seaboard, eleven having been constructed on the Atlantic and two on the Pacific.

These thirteen have an aggregate of 45,864 gross tons, or an average of 3,528. If we omit the gigantic *Dakota,* the construction of which having extended over several years belongs properly to a previous period, we have twelve ships of an aggregate of 25,150 tons or an average of 2,096. Compared with this, we have on the Great Lakes a splendid array of thirty ships, aggregating 171,018 tons, or an average of 5,701. This average is greater than the tonnage of the largest ship built on the seacoast, with the sole exception of the *Dakota,* while the smallest of these thirty lake ships has a greater tonnage than the average on the seaboard, if we omit the *Dakota.* The next smallest on the lakes has a greater tonnage than the average on the seaboard, even including the *Dakota.* It will further be noted that with the sole exception of the *Dakota* every one of the ships built on the seaboard is designed for either coastwise traffic or ferryboat or similar service.

We have received from a number of the important seacoast shipyards of the United States information regarding the shipping in hand at the close of the year, and we present this in a fourth table which explains itself. It will be noted that the table represents 27 ships of a gross tonnage amounting to 98,215, or an

average of 3,638 tons, besides 17 ships, mostly small, of which the tonnage is not given. This is in addition to warships aggregating 28 in number, with a total displacement of 313,350 tons.



THE TREND OF MERCHANT SHIPBUILDING.

On the lakes orders are in hand for thirty-one large steel ships under contract to come out in the spring and early summer of 1906. Twenty-six of these ships have been ordered from the American Shipbuilding Company, four from the Great Lakes Engineering Works, and one from the Craig Shipbuilding Company, Toledo. It is estimated that these thirty-one vessels will be able to carry about 270,000 gross tons per trip, or a total of 5,400,000 tons during the season. The total cost is placed at $10,500,000. With the exception of one of these ships, which is a package freighter, all are designed for bulk cargo in the shape of ore and grain.

FORE RIVER SHIPBUILDING CO., QUINCY, MASS.

Ship.	Tons Gross.	Length.	Knots.	Owner.
Creole (*a*).....	6,000	440	16	Southern Pacific Co.
South Shore, (*b*)....	750	208	15	Nantasket Beach Co.

MARVEL SHIPBUILDING CO., NEWBURG, N. Y.

Hudson River Day Line steamer (hull only).

ROACH SHIPYARD, CHESTER, PA.

	Tons Gross.	Length.	Knots.	Owner.
Steamer	3,000	285	14	New England Nav. Co.
Steamer (*a*).....	3,650	305	17.5	Eastern S. S. Co.
Steamer (*a*).....	4,800	405	20	Metropolitan S. S. Co.
Steamer (*a*).....	4,800	405	20	Metropolitan S. S. Co.

WILLIAM CRAMP & SONS, PHILADELPHIA.

	Tons Gross.	Length.	H.P.	Owner.
Transfer tug.....	276	112	1,000	N. Y., N. H. & H. R. R.
John Weaver.....	1,700	200	3,800	City of Philadelphia.
Two steamers.....	7,000	400	6,000	N. Y. & Cuba Mail.
Two steamers.....	7,200	413	8,500	N. Y. & Cuba Mail.
Two steamers.....	7,500	421	7,000	Southern Pacific Co.
Three steamers.....	3,500	375	7,600	Quintard Iron Works.

NEW YORK SHIPBUILDING CO., CAMDEN, N. J.

One suction dredge for Atlantic, Gulf & Pacific Co.
Two suction dredges for Empire Engineering Co., New York.

MARYLAND STEEL CO., SPARROWS POINT, MD.

	Tons Gross.	Length.	H.P.	Owner.
Delaware (dredge)..	2,700	300	.....	United States.
Three tugs.....	.....	91	.....	Pennsylvania R. R. Co.
One tug.....	.....	106	.....	Pennsylvania R. R. Co.
One float.....	.....	340	.....	Pennsylvania R. R. Co.
Two floats.....	.....	185	.....	Standard Oil Co.
Six floats.....	.....	111	.....	Panama R. R. Co.

NEWPORT NEWS (VA.) SHIPBUILDING AND DRYDOCK CO.

	Tons Gross.	Length.	Knots.	
Syracuse.....	450	101	9(*c*)	(freight lighter)
W. S. Porter.....	4,527	385	11	(freighter)
Jamestown.....	1,400	250	18(*c*)	(passenger steamer)
Ferryboat.....	1,462	231	15(*c*)	

UNION IRON WORKS, SAN FRANCISCO, CAL.

	Tons Gross.	Length.	Owner.
Mexican.....	4,400	360	American-Hawaiian S. S. Co.
Columbian.....	4,400	360	American-Hawaiian S. S. Co.

(*a*) Propelled by Curtis steam turbines. (*b*) Propelled by paddle-wheels. (*c*) Miles per hour.

Marine Thrust Bearings.*

G. W. DICKIE: Judging from the rapid introduction of the steam turbine for ship propulsion, the thrust bearing, which has played so important a part in marine steam engineering, is in danger of losing its importance in marine engine design, the thrust of the propeller on the one end of the shaft being balanced by the thrust of the turbine on the other end. This "defect" in the Parsons turbine, the end thrust, is a great advantage when applied to screw propelled ships, for it balances the thrust of the screw, thus saving the very material loss by friction of the thrust bearing, and renders the Parsons turbine an ideal form of motor for ships. Still for some time to come we will require thrust bearings for marine engines, and an inquiry as to what the main features in a well-designed bearing of this character should be will be time well spent.

The marine thrust bearing has not changed in type since the introduction of screw propulsion, although many attempts have been made to introduce some kind of ball or roller bearing with the object of reducing the friction of the extended rubbing surface of the bearing, but no one of such devices has succeeded in permanently taking the place of the collar and ring thrust. The adoption of the horseshoe ring, better workmanship, and improved methods of lubrication, together with water-cooling devices, have brought the marine thrust bearing to its present efficiency.

The function of the thrust bearing renders it difficult to experiment with for data; it has, therefore, developed along the line of meeting pressure with surface, making provision so that all the surface involved will take load, lubricating and watching the result. In computing the pressure on a thrust bearing the usual practice is to find the indicated thrust, assuming two-thirds of the indicated horsepower to be effective; the result will be somewhat in excess of the actual thrust even in the best of cases, the pressure on thrust bearings being,

$$P = I.H.P. \times \frac{2 \times 60 \times 33{,}000}{S \times 3 \times 6{,}080} = 217 \frac{I.H.P.}{S}$$

where P = pressure on thrust bearing, S = speed of ship in knots. Applying this to several types which cover general practice, and which I have taken from my own work which proved to be satisfactory:

I. Armored cruiser, speed.....	22 knots
Thrust ring surface, horseshoe type.....	1,188 square inches
Horsepower, one engine.....	11,500
Indicated pressure or thrust on bearing..	112,700 pounds
Pressure per square inch of surface.....	95 pounds
Mean speed of bearing surfaces.....	642 feet per minute

This would represent fairly naval marine engine practice, and, under the full power conditions as given above, the thrust bearing needs careful watching. The length of the bearing proper, from the after face of the after horseshoe to the after face of the forward horseshoe, being 72 inches, the danger is that any part of the bearing getting hot may so change the relative distance between the shaft collars and the thrust rings as to disturb the distribution of load and leave part of the bearing out of service. I think that I was the first to make the horseshoe rings with an independent circulation of cooling water through each ring. This enables the attendant to control the heat of each ring independently, and thus maintain an even temperature throughout the whole bearing. The base of the bearing forms an oil reservoir, the bearing at each end having a stuffing box so that the oil can be carried above the lower line of the shaft; a cold water coil is fitted in the oil chamber to keep down the temperature. I find that a small surface is sufficient for this purpose where the horseshoe rings are fitted with water circulation. The bearing noted above has 15 feet of cooling surface for the lubricating oil.

*Discussions before American Society of Mechanical Engineers, December 7, 1905.

II. Protected cruiser, speed	22½	knots
Thrust ring surface, horseshoe type	891	square inches
Horsepower of one engine	8,600	
Indicated pressure or thrust on bearing	89,000	pounds
Pressure per square inch of surface	100	pounds
Mean speed of bearing surfaces	610	feet per minute

This bearing was fitted with independent water circulation through each horseshoe ring like the first case, and with 10 feet of cooling surface for the lubricating oil the working proved very satisfactory, the thrust bearing requiring no more care than the other bearings of the engine.

III. Torpedo boat destroyer, speed	28	knots
Thrust ring surface, complete rings	581	square inches
Horsepower of one engine	4,200	
Indicated pressure or thrust on bearing	33,600	pounds
Pressure per square inch of surface	58	pounds
Mean speed of bearing surfaces	827	feet per minute

This bearing was fitted with a complete water jacket and required a large stream of water to control the temperature at full power, and constant care was necessary during the two hours' full-power run. It will be noted that the pressure per square inch of surface was much less than that of the other cases, but the surface velocity was much higher.

IV. First-class modern passenger ship, speed	21	knots
Thrust ring surface, horseshoe rings	2,268	square inches
Horsepower of one engine	15,000	
Indicated pressure or thrust on bearing	154,500	pounds
Pressure per square inch of surface	68.1	pounds
Mean speed of bearing surfaces	504	feet per minute

In this case there is no independent water circulation through the horseshoe, and the bearing gives no unusual trouble. It will be noted that in this case the bearing surface speed is less than in the others, and consequently lubrication is more certain.

There is considerable difference in the practice of prominent marine engine builders in regard to thrust bearings, but generally it will be found that for steady work the pressure per square inch of surface should not exceed 75 pounds with a speed of 500 feet per minute.

A. M. Mattice: The central gravity system of lubrication which has come into extensive use in engine installations within the past few years has resulted in a marked saving in cost of lubrication and the elimination of bearing troubles, and the details of such systems are well worth the serious attention of engineers. I refer to the systems which, while varying in details, comprise essentially an overhead supply tank, pipes leading to all bearings with valves for regulating the supply, arrangements for catching the overflow oil, settling tanks, filters, and pumps for returning the oil to the supply tank; the whole system being automatic, and resulting in a continuous circulation of oil. Although this system is at present used principally in large installations, it has been used with success in smaller plants, and I believe that engineers would be fully justified in using it in installations of single engines of large or even moderate size. Its success is due not only to the saving of labor, as in large installations, but by supplying an excess of oil to the bearings the oil does not become "worn out," as in the drop-by-drop system, resulting in a reduction of oil bills.

A further extension of the principle of continuous circulation of oil obtains in the flooded system of lubrication which has come into use in connection with steam turbines. In fact, this system was introduced by Parsons before the central gravity system for reciprocating engines came into vogue. This system consists in supplying to the bearings as much oil as will flow through them; the oil carrying away the heat of the bearings and being cooled in a tubular cooler before going back to the bearings again. The oil is not forced into the bearings under pressure, but simply supplied at a head of from a few inches to several feet—just enough to allow it to flow freely to the bearings. As the oil is nowhere exposed to the outside air, circulating only in a closed system, it collects no dirt and does not need to be filtered, but is used over and over again continuously, the entire oil supply circulating through the bearings every few minutes.

By means of the system, speeds and pressures are used which would otherwise be impossible, and, what is of still greater interest to the owner, the oil consumption is reduced to a minimum. As instances of this I would cite the cases of two installations of 400-kilowatt steam turbines of the Parsons type, running at 3,600 revolutions per minute; one used only 50 gallons of oil in six months, and the other one 55 gallons. At another plant one turbine of 40 kilowatts and another of 750 kilowatts used only three barrels of oil in sixteen months. In another case two 1,000-kilowatt turbines used one-half gallon of oil per turbine-week.

I crossed the Atlantic last summer in the turbine steamer *Virginian,* and upon investigating I found that no oil had been added to the tanks for four successive round trips between Liverpool and Montreal, and the supply had not appreciably diminished. The service tank has a total capacity of 293 United States gallons, but only 144 gallons of oil had been put in, and this was being circulated through the bearings at the rate of from 40 to 50 gallons per minute, the whole supply being circulated in less than every four minutes.

The turbine steamer *Queen Alexandra,* which in the summer season makes daily trips on the Clyde, used less than one barrel of oil during a season of between four and five months.

The oil consumptions of turbine steamers above quoted are for the bearings of the turbines proper, each steamer having three turbines. The line shaft bearings have ordinary lubrication, but I have no doubt that before long it will become the practice to use on such bearings the same system of flooded lubrication as on the bearings of the turbines themselves.

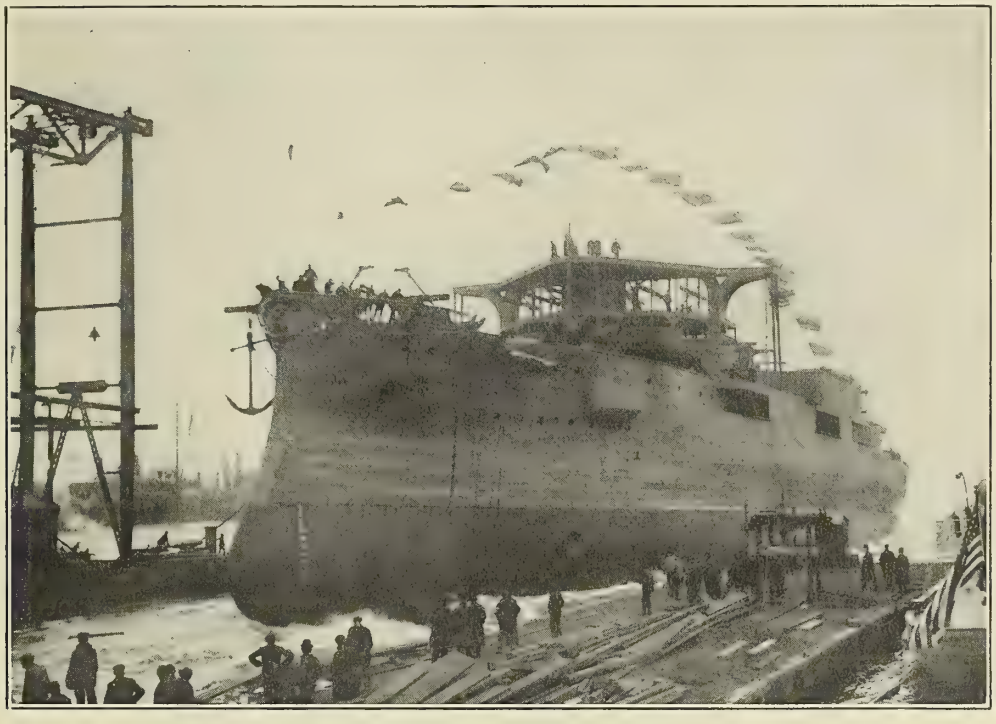
The Battleship Agamemnon and Beardmore's New Shipyard.

The construction of the new battleship *Agamemnon* inaugurates the new naval construction works of Messrs. William Beardmore & Company, Limited, at Dalmuir, near Glasgow. The event is of some historical interest. This ship is the first battleship designed by Mr. Philip Watts, as Director of Naval Construction. She will be the most powerful ship of the line in existence, and she is the first warship to be commenced at the new works of the Beardmore company. The *Agamemnon* is to be 410 feet long between perpendiculars, and her displacement at 27 feet draft will be 16,500 tons. She will have the greater part of her length broadside armored with hardened plates varying from 9 inches to 7 inches in thickness from over 5 feet below the waterline to the upper deck. Her extremities will be protected by armor varying in thickness down to 4 inches. Her armament of four 12-inch guns is to be in pairs in centrally located barbettes forward and aft, while on each broadside there will be five 9.2-inch guns. For bow or stern firing there will be two 12-inch and four 9.2-inch weapons, and for broadside attack four 12-inch and five 9.2-inch pieces will be available. The guns will be of longer caliber than in any recent ships, and will develop a greater energy. The propelling machinery is to be of 16,750 indicated horsepower, to give a speed of 18 knots.

The new works at which the building of this ship has been commenced are of the most up-to-date character. Steam is dispensed with and power is generated in immense gas engines worked with producer gas. The producers also supply the gas for the furnaces, where plates, angles, etc., are worked to form. The engines drive Vickers electric generators, which provide the power for the motors at the machine tools, cranes, etc. The smith and forging hammers are operated by air, and the compressors are actuated also by gas engines. In the arrangement and equipment of the works the most approved practice has been adopted.

Naval construction at their works follows the conclusion of the

long career of Napier's yard and the Lancefield Forge and Engine Works recently acquired by the Beardmore company and now dispensed with in favor of the new establishment. The oldest foreman in the old Lancefield works was employed to cut off steam from the engine with the ceasing of active life in one of the oldest engine works in the country. The famous Robert Napier leased Lancefield from his cousin David in 1835 for £500 a year, with the option of a sale for £20,000. From the old works there have been sent forth many historical engines, including those for all the Cunard liners up to the last of the paddle engines, and the first of triple-expansion engines for liners and warships. The Govan yard was opened in 1842, the first ship being the *Vanguard,* of 700 tons, for the Glasgow and Dublin trade, followed by a long series of successes in merchant and naval ships. Under the Beardmore company these establishments are now associated with the Beardmore armor plate and forging businesses.



THE IDAHO LEAVING THE WAYS.
(Photo. W. H. Rau.)

The Launching of the Idaho.

On Saturday, December 9, 1905, the New United States battleship *Idaho* was launched from the ways of the Wm. Cramp & Sons' Ship & Engine Building Company, of Philadelphia.

The *Idaho* is a first-class battleship, having a length of 375 feet, a beam of 77 feet, and a mean draft of 24 feet 8 inches, corresponding with a displacement under normal conditions of 13,000 tons. She is to be propelled by twin-screw, triple-expansion engines, giving an indicated horsepower of 10,000 and providing the ship with a speed of 17 knots. The normal coal supply amounts to 600 tons, while the total bunker capacity is estimated at 1,750 tons.

The ship has a battery consisting of four 12-inch, eight 8-inch and eight 7-inch breech-loading rifles; with a secondary battery containing twelve 3-inch, six 3-pounder, four 1-pounder, eight machine and two field guns, with two 18-inch submerged torpedo tubes.

The armor consists of a waterline belt having a thickness amidships of 9 inches, with thinner armor above the belt, forming a casemate. The barbettes for the 12-inch guns have a thickness of 10 inches on the face and 7½ inches in the rear, with corresponding turrets 12 inches and 8 inches in thickness. For the 8-inch guns the barbettes have a thickness of 6 and 4 inches respectively, and turrets 6½ and 6 inches. The protective deck has a thickness of 3 inches on the slopes and 1½ inches on the flat. The complement consists of thirty-four officers and six hundred and ninety-one men.

The *Idaho* is in all respects similar to the *Mississippi,* description of which was published at page 467 in our November number.

A Boiler Tube Question.—The relative merits of vertical and horizontal boiler tubes have been before the North of England Institution of Shipbuilders and Engineers. In a comparison of vertical and horizontal tubes, in water-tube boilers, many controversial points were raised, and in respect to fuel economy it was contended that vertical tubes, small in diameter, are preferable to horizontal ones. But it was admitted that it is equally important that the gases, on leaving the combustion chamber to enter among the tubes, should not rush through to the funnel too quickly, but that enough time should be allowed them to give up their heat. This is characterized as the crux of the efficiency question in all vertical tube boilers, and is the reason why the horizontal tube boiler with baffles has been preferred for practically all but light craft, where the minimizing of weight is a dominant consideration. The gases should be split up into as many narrow streams as possible. A reduction in scantlings involves sacrifices of durability and of safety; less water space is against accessibility, and a smaller steam drum tends to wet steam; indeed, it is said that the small steam space in boilers has given the whole class of steam generators a bad name. Flat-stayed surfaces are probably the most expensive item in boiler work; but there are only two or three boilers of less known types with these. The securing of tubes by expansion rather than by screwing them into the tube plate or header is cheaper. Casings when brick lined are costly, and bricks are not always suitable on board ship. Straight tubes are preferable for cleaning internally, and vertical tubes have an advantage, as they have the minimum amount of external deposit. The horizontal tube generally lends itself well to renewal, as with vertical tubes it frequently happens that good tubes have to be cut away to get at a defective one. But each type must be considered on its individual merits, and upon the predominant qualities of each particular case. A boiler suited to a destroyer would not do for a tramp steamer.

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The edition of the January issue of MARINE ENGINEERING *comprises 5,500 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand, so that the 5,500 copies represent legitimate circulation.*

Shipbuilding in the United States.

In another column we have given a résumé of the shipbuilding situation in the United States, both as regards ships constructed during the year 1905, and those in hand at the present time. The situation on the seacoast is very far from encouraging. It will be seen by reference to the tables and the diagram presented that the tonnage constructed for sea-going traffic has undergone a continuous decrease during the past three or four years, and has reached a point where a much further decrease would result in its total disappearance. We do not anticipate any such result as this, however, because there will always be a certain amount of work in connection with providing ships for coastwise traffic; but so far as over-sea trade is concerned, the amount of shipbuilding seems likely to diminish to zero unless something is done to relieve the situation. Fortunately, it begins to appear likely that Congress will at the present session take up seriously the shipping question, and it is believed in quarters usually well informed on such subjects that some sort of relief will be afforded by means of a bill passed. Unless something of this sort comes to a head, we may certainly look for an absolute cessation in American shipyards of all work covering transoceanic traffic. Conditions have reached almost the lowest possible ebb, so that they cannot be very much worse than they are at present, and any change which may be made must be for the better. We are exceedingly hopeful of some assistance from Congress through the medium of the merchant marine bill, and sincerely trust that nothing may intervene to prevent its speedy passage.

On the lakes no such condition exists. The yards are very busy, having in many cases all the work they can handle for the next year, and, with the immense expansion of the iron and steel business which has been taking place during the present year, and which furnishes a very large proportion of the freight carried by these steamers, there is not in sight any cause which might lead us to expect a retardation of this business. Such action as Congress may take in the matter will not affect lake shipping in the least, nor is there any reason why it should be expected to do so; but this particular phase of the shipping industry, giving us as it does a splendid indication of what that industry can be made under proper conditions, ought to give us great encouragement with regard to what the situation on the seacoast will be when the merchant marine bill finally becomes a law.

Naval Engineers.

In his report, the Chief of the Bureau of Steam Engineering in the Navy Department takes up the question of naval engineers, which he admits to be in a critical condition. Recognizing the fact that at the time of the enactment of the personnel bill a whole corps of specialists was virtually abolished, and the duties previously performed by these specialists transferred to the line, the intent of that bill is stated to have had in view the perfecting of all the younger officers of the engineering corps in seamanship, gunnery and navigation; and at the same time the younger officers of the line were to perfect themselves in engineering duties, and thereafter all of these officers of both divisions were to perform indiscriminately the joint duties. It was expected that this would result eventually in providing a line composed wholly of officers fitted to perform all duties connected with the movement of ships.

The younger officers of the engineer corps, in the two years in which they were given to qualify for their new duties, attained an eminent fitness for them, and it may be said that all officers now in the navy are properly qualified to perform the duties usually devolving upon the line officer.

On the other hand, as all midshipmen at the academy had been given during their course excellent practical instruction in engineering, no additional examination was demanded of them, except that required for promotion, in order to prove their qualifications for the performance of the new duties thrust upon them. The

intent was, however, that they should be ordered at once to the performance of this duty in subordinate capacities as assistants to the older engineer officers. Owing to the absence of specific instructions to that effect in the personnel bill, combined with powerful adverse influences within the department itself, it resulted that for three years absolutely nothing was done by the younger line officers, in the direction of acquiring engineering experience; and later, owing to the large number of ships kept in commission, and the relative scarcity of officers for all duties, little in that direction has been accomplished.

In the meanwhile the older officers of the engineer corps, partly by retirement and partly by promotion to a rank at and beyond which they could not legally be called upon for sea duty, have dwindled to a mere handful; so long as they remained available for service at sea, and were supplemented by the new body of warrant machinists, the engineering duty of the fleet was properly performed. At the present time, however, there are so few of the old officers available for service, and so few of the younger line officers have attained any considerable degree of perfection in engineering experience, that the conduct of the machinery of our ships is entrusted for the most part to warrant machinists, supervised in the larger class of vessels by in many cases a single officer of responsibility, and the number of such officers is rapidly diminishing, having been sixty-six a year ago and only forty-three at the present time. So few officers of the line are taking up engineering seriously that the situation is becoming positively alarming.

The Bureau recommends that there be no formation of a separate corps of engineers; and that there be a large increase in the number of warrant machinists. We are fully in accord with the latter recommendation, for the reason that the only method apparent for providing the immediate increase in the engineering staff which the conditions of the service render absolutely necessary seems to be an increase in this branch. As to the formation of a second corps of engineers, that subject is decidedly open to argument. As we have pointed out time and again, the position is one calling for a very highly trained class of specialists. It has been suggested that all officers of the navy be made engineers first, and line officers afterward. This would provide for the specialists required, and would be eminently logical; for the subjects not covered by regular duties of engineer officers are such that men of the caliber of those graduated from Annapolis can quickly acquire proficiency in them. It would thus seem advisable to follow out the Bureau's suggestion of not forming a separate corps of engineers but of making all officers engineers. This would provide our ships with commanders and other officers who would be thoroughly conversant with the demands of the engineering service, and would further result in entirely eliminating a great deal of the friction and misunderstanding unavoidably connected with the present method of handling the ships. It would, furthermore, result in placing the engineering force as such under the command of officers responsible for the ship as a whole, instead of placing them under the dual command of engineering officers without authority beyond their own departments, and line officers claiming authority in every department, and, in many cases, thoughtlessly issuing orders decidedly prejudicial to the proper conduct of the engineering department.

The Bureau recommends that there be no introduction of outsiders into the engineering personnel, believing that graduates of the Naval Academy can fulfil all duties required. This recommendation is not supported by the Secretary of the Navy in his annual report. He recommends that for engineering duty on shore, such as the designing of marine engines and boilers and the inspection of constructions and material, there be organized a corps of men from civil life, graduates of our great technical schools, who shall be given this duty in order to release from it for sea duty engineering graduates of Annapolis. This recommendation of the Secretary seems to us a very good one, and we hope it will prove but an entering wedge providing for a much larger use in the navy of our technical graduates, under conditions such that they can reasonably be expected to take up this work with the intention of making it a life work. This wish is actuated by our thorough belief that the resources of the Naval Academy for providing a sufficient number of engineer officers well trained for the duties required of them are totally inadequate to the needs of the situation; besides which the experience necessary for placing these officers in positions of responsibility cannot be obtained without the expenditure of a considerable amount of time; and we believe that this time is not available: the situation demands immediate relief.

In conversation some days ago with one of the old engineer officers of the navy, now retired, the Editor was informed by this officer that the first ship of which he had the honor to be chief engineer had machinery of 800 horsepower. He had as assistants four graduates of Annapolis, who were serving in subordinate capacities under him and acquiring the necessary engineering experience to fit them for the duties which ultimately fell to their lot. The last engineering assignment of this officer before his retirement saw him as chief engineer of one of our latest battleships, whose engines indicated on trial about 12,000 horsepower, or fifteen times as much as in the first case. His assistants consisted of four warrant machinists, all practical men, but not one of them a man capable of achieving command-rank in engineering, and not one of them, of course, a graduate of Annapolis. This single comparison is a sufficient index as to the way things have been running in the engineering side of the navy during the past few years.

Give us engineers, and that right away!

ABSTRACTS FROM RULES AND REGULATIONS OF THE GREAT LAKES REGISTER.

EDITION OF 1904.

ARRANGED BY HARRISON S. TAFT.

(Continued.)

36. Spacing of Rivets.

DIAS.

1. Center of rivets from edge of plate or angle bar..... 1½
2. Butts of the shell plating. All butt straps..... 3½
3. Longitudinal seams or laps of the shell plating; of the deck plating; of the tank-top plating; of all watertight bulkheads; and of all other watertight work..... { Single riveted.. 3½ / Double " .. 4
4. Beam knees to beams and frames; tank-top frame and web-frame bracket plates; keelson angle bars to a flat-plate keel; rudder rivets..... 5
5. Bar keels; stems; stern posts (zigzag fashion)..... 5
   Center to center of rows..... 3
6. Frames to reverse bars; angle bars to hold stringers; water-bottom longitudinals; steel decks and stringers to beams; shell plating to frames..... 7
7. The third row of a treble-riveted butt strap and the fourth row of a quadruple-riveted butt strap may be spaced 1 1-2 times the spacing of the other rows.
8. The spacing of rivets in each row of an overlapped butt must be the same.
9. When the side keelsons are fitted with treble-riveted double butt straps, the spacing of the third row may be twice that of the other two rows.
10. When the width of a quadruple-riveted butt strap exceeds the frame spacing, the fourth row which passes through the frame can be spaced 1 1-2 times the spacing of the other rows.

TABLE 7.—GREAT LAKES REGISTER. WIDTH OF BUTT LAPS AND BUTT STRAPS. SPACING OF RIVETS.

	Weight of Plate in Lbs.	Diametral Pitch.	10 to 12½	15 to 20	22½ to 25	27½ to 32½	35 to 40
	Diameter of Rivets for Plate and Angles. Inches.		⅝	¾	⅞	1	1⅛
	Diameter of Rivets for Stems: Stern Posts: Bar Keels. See No. 5 below.		⅞	[a] 1 and 1⅛	1⅛	1¼	1¼
Width of:	Single riveted butt laps		....	....	....	....	....	....
	Double " " "		6½	4	5	5¾	6½	....
	Treble " " "		....	6	7¾	8¾	10	11½
	Quadruple " " "		....	....	10½	11¾	13¾	15½
	Double " " straps		....	8	10½	11¾	13¾	15
	Treble " " "		....	12½	15¾	17½	20½	23
	Quadruple " " "		....	....	22	24	27½	31½
	Single " edge laps		....	2¼	2¾	....	....	....
	Double " " "		6½	4	5	5¾	6½	7¼
	Single " " strips		....	....	....	....	....	....
	Double " " "		....	....	....	....	....	....
Spacing of rivets.	1.—Center of rivet from edge of plate or angle bar		1½	1 5/8	1⅛	1 5/16	1½	1 11/16
	2.—Butts of the shell plating. All butt straps		3½	2 5/8	2⅝	3 1/16	3½	3 1/16
	3.—Longitudinal seams or laps of the shell, deck and tank top plating. All other watertight work { Single riveted		3½	2 1/16	2⅝	3 1/16	3½	3 1/16
	{ Double "		4	2½	3	3½	4	4½
	4.—Beam knees; tank top frame bracket plates: Keelson angle bars to a flat plate keel: rudder rivets		5	3⅜	3¾	4⅜	5	5⅝
	5.—Bar keels; stems: stern posts. Zigzag		5	3⅛	3¾	4⅜	5	5⅝
	Center to center of rows		3	1⅞	2¼	2⅝	3	3⅜
	6.—Frames to reverse bars; angle bars to hold stringers; water bottom longitudinals; steel decks and stringers to deck beams; shell frame rivets		7	4⅜	5¼	6⅛	7	7⅞
Spacing of rivets. Oil tanks only.	1.—Longitudinal seams of the shell plating; butts and seams of the "crown deck" plating; butts and seams of all bulkheads made oiltight		3½	2 3/16	2⅝	3 1/16	3½	3 15/16
	2.—Oiltight bulkhead frame bars; corner angles and collars; bulkhead stiffeners to be caulked		4	2¼	3	3½	4	4½
	3.—Butts and seams of a center line bulkhead not made oiltight; deck beam knee brackets; all other brackets worked to maintain continuity of strength		4½	2 13/16	⅜	3 15/16	4½	5 1/16
	4.—Bulkhead stiffeners not caulked		6	3¾	½	5¼	6	6¾
	5.—Frame and deck beam rivets		6¾	4 1/16	4⅞	5 11/16	6½	7 5/16
	6.—Single frame bars at web frames. Zigzag		7	4⅜	5¼	6⅛	7	7⅞

[a] 15 and 17½ lbs. = 1" rivet. 20 lbs. = 1⅛" rivet.

PART II.

OIL VESSELS.

37. General.

1. The oil should go to the skin of the ship. When double bottoms are adopted said spaces must be well ventilated.
2. An oiltight longitudinal center-line bulkhead should be fitted in all vessels carrying an oil cargo. Said bulkhead is to extend from the keel to the top of the expansion trunk.

TABLE 8.—RIVETING SCHEDULE FOR BUTT STRAPS.

LENGTH OF VESSELS.

72	Depth.	5	6	7
	Flat plate keel and garboards	T R—¾ L	T R—¾ L	T R—½ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—½ L	D R—T	D R—T
	Sheer strake; stringers and ties	T R—½ L	D R—T	D R—T
	Center vertical keelson	T R—½ L	D R—T	D R—T
	Side keelsons	D R—T	D R—T	D R—T
96	Depth.	6	7	8
	Flat plate keel and garboards	T R—¾ L	T R—¾ L	T R—½ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—½ L	D R—T	D R—T
	Sheer strake; stringers and ties	T R—½ L	D R—T	D R—T
	Center vertical keelson	T R—½ L	D R—T	D R—T
	Side keelsons	D R—T	D R—T	D R—T
120	Depth.	8	9	10
	Flat plate keel and garboards	T R—T	T R—T	T R—½ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—½ L	T R—¾ L	D R—T
	Sheer strake; stringers and ties	T R—½ L	T R—¾ L	D R—T
	Center vertical keelson	T R—½ L	T R—¾ L	D R—T
	Side keelsons	D R—T	D R—T	D R—T
144	Depth.	9	11	13
	Flat plate keel and garboard	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—½ L	T R—½ L
	Sheer strake; stringers and ties	T R—¾ L	T R—½ L	T R—½ L
	Center vertical keelson	T R—¾ L	T R—¾ L	T R—½ L
	Side keelsons	D R—T	D R—T	D R—T
168	Depth.	11	12	14
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—¾ L	T R—½ L
	Sheer strake; stringers and ties	T R—¾ L	T R—½ L	T R—½ L
	Center vertical keelson	T R—¾ L	T R—½ L	T R—½ L
	Side keelsons	T R—½ L	D R—T	D R—T
192	Depth.	12	14	16
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—¾ L	T R—½ L
	Sheer strake; stringers and ties	T R—¾ L	T R—½ L	T R—½ L
	Center vertical keelson	T R—¾ L	T R—½ L	T R—½ L
	Side keelsons	T R—½ L	D R—T	D R—T
216	Depth.	14	16	18
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—½ L	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—¾ L	T R—½ L
	Sheer strake; stringers and ties	T R—T	T R—¾ L	T R—½ L
	Center vertical keelson	T R—¾ L	T R—½ L	T R—½ L
	Side keelsons	T R—½ L	D R—T	D R—T
240	Depth.	15	17	20
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—½ L	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—¾ L	T R—½ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—¾ L
	Center vertical keelson	T R—¾ L	T R—¾ L	T R—½ L
	Side keelsons	T R—½ L	D R—T	D R—T
264	Depth.	17	19	22
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—½ L	T R—½ L	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	a. T R—¾ L	T R—T	T R—¾ L
	Center vertical keelson	T R—T	T R—¾ L	T R—½ L
	Side keelson	a. T R—¾ L	T R—½ L	D R—T
288	Depth.	18	21	24
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—½ L	T R—½ L	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	a. T R—¾ L	a. T R—½ L	T R—T
	Center vertical keelson	T R—T	T R—T	T R—¾ L
	Side keelsons	a. T R—¾ L	a. T R—¾ L	a. T R—½ L

LENGTH OF VESSELS.

312	Depth.	20	23	26
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—½ L	T R—½ L
	Bilge plating	T R—T	T R—T	T R—¾ L
	Sheer strake; stringers and ties	T R—¾ L	T R—½ L	T R—¾ L
	Center vertical keelson	T R—T	T R—T	T R—¾ L
	Side keelsons	T R—¾ L	T R—¾ L	T R—¾ L
336	Depth.	21	25	28
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—½ L	T R—½ L
	Bilge plating	T R—T	T R—T	T R—¾ L
	Sheer strake; stringers and ties	T R—¾ L	T R—½ L	T R—¾ L
	Center vertical keelson	T R—T	T R—T	T R—T
	Side keelsons	T R—¾ L	T R—¾ L	T R—¾ L
360	Depth.	23	28	30
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—¾ L	T R—¾ L
	Bilge plating	T R—T	T R—T	T R—¾ L
	Sheer strake; stringers and ties	T R—¾ L	T R—¾ L	T R—½ L
	Center vertical keelson	T R—T	T R—T	T R—T
	Side keelsons	T R—¾ L	T R—¾ L	T R—¾ L
384	Depth.	24	26	32
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—¾ L	T R—¾ L
	Bilge plating	T R—T	T R—T	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—¾ L	T R—¾ L
	Center vertical keelson	T R—T	T R—T	T R—T
	Side keelsons	T R—¾ L	T R—¾ L	T R—¾ L
408	Depth.	26	31	34
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—¾ L
	Bilge plating	T R—T	T R—T	T R—T
	Sheer strake	T R—T	T R—T	T R—¾ L
	Stringers and ties	Quad—½ L	Quad—½ L	T R—¾ L
	Center vertical and side keelsons	T R—T	T R—T	T R—T
432	Depth.	27	32	36
	Flat plate keel and garboards	Quad—½ L	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—½ L	T R—T	T R—T
	Sheer strake	Quad—½ L	T R—T	T R—T
	Stringers and ties	Quad—¾ L	Quad—½ L	T R—T
	Center vertical and side keelsons	T R—T	T R—T	T R—T
456	Depth.	28	32	36
	Flat plate keel and garboards	Quad—¾ L	Quad—½ L	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—½ L	T R—T	T R—T
	Sheer strake	Quad—½ L	Quad—½ L	T R—T
	Stringers and ties	Quad—¾ L	Quad—¾ L	Quad—¾ L
	Center vertical and side keelsons	T R—T	T R—T	T R—T
480	Depth.	30	33	36
	Flat plate keel and garboards	Quad—¾ L	Quad—½ L	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—¾ L	Quad—½ L	Quad—½ L
	Sheer strake	Quad—¾ L	Quad—¾ L	Quad—½ L
	Stringers and ties	Quad—¾ L	Quad—¾ L	Quad—½ L
	Center vertical and side keelsons	T R—T	T R—T	T R—T
504	Depth	30	33	36
	Flat plate keel and garboards	Quad—¾ L	Quad—¾ L	Quad—½ L
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—¾ L	Quad—¾ L	Quad—½ L
	Sheer strake	Quad—¾ L	Quad—¾ L	Quad—¾ L
	Stringers and ties	Quad—¾ L	Quad—¾ L	Quad—¾ L
	Center vertical and side keelsons	T R—T	T R—T	T R—T

1. Tank top center line and margin strakes plates are to be double riveted throughout in all cases.

2. Double butt straps are to be fitted to the center vertical keelson in all cases.

3. Double butt straps are to be fitted to the sheer strake, to the stringers and ties, and to the side keelsons in all vessels of 312 feet or more in length. Also as indicated below.

a. Double butt straps. D R — T = double riveted throughout. T R — T = treble riveted throughout. T R — ½ L = treble riveted for ½ length amidships. T R — ¾ L = treble riveted for ¾ length amidships. Quad — ½ L = quadruple riveted for ½ length amidships. Quad — ¾ L = quadruple riveted for ¾ length amidships.

3. The fore-and-aft dimension of each oil tank in a steamer should not exceed 28 feet.

4. An expansion trunk must be fitted to each and every oil tank. Said expansion trunks are to extend above the "crown deck," having a capacity of not less than 6 per cent. of that of the corresponding oil tank to which they are fitted.

5. There must be a cofferdam at each end of the spaces devoted to an oil cargo, extending the entire breadth of the ship. Said cofferdams are to be at least two frame spaces wide, and are to extend to the top of the expansion trunk.

6. Each compartment must be tested by a head of water 11 feet above the crown of the tank, or 4 feet above the expansion trunk hatch covers.

TABLE 9.—RIVETING SCHEDULE FOR BUTT LAPS.

LENGTH OF VESSELS.

72	Depth.	5	6	7
	Garboards	T R—T	T R—T	T R—¾ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—⅞ L	D R—T
	Sheer strake; stringers and ties	T R—⅞ L	T R—⅞ L	D R—T
	Center vertical keelson	T R—¾ L	T R—⅞ L	T R—½ L
	Side keelsons	T R—½ L	D R—T	D R—T
	Tank top center and margin plates	D R—T	D R—T	D R—T

96	Depth.	6	7	8
	Garboards	T R—T	T R—T	T R—¾ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—⅞ L	D R—T
	Sheer strake; stringers and ties	T R—⅞ L	T R—⅞ L	D R—T
	Center vertical keelson	T R—¾ L	T R—⅞ L	T R—½ L
	Side keelsons	T R—½ L	D R—T	D R—T
	Tank top center and margin plates	D R—T	D R—T	D R—T

120	Depth.	8	9	10
	Garboards	T R—T	T R—T	T R—¾ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—T	T R—⅞ L	T R—⅞ L
	Sheer strake; stringers and ties	T R—⅞ L	T R—⅞ L	T R—½ L
	Center vertical keelson	T R—¾ L	T R—¾ L	T R—½ L
	Side keelsons	T R—½ L	T R—½ L	D R—T
	Tank top center and margin plates	D R—T	D R—T	D R—T

144	Depth.	9	11	13
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—T	T R—⅞ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—⅞ L	T R—¾ L
	Center vertical keelson	T R—T	T R—¾ L	T R—¾ L
	Side keelsons	T R—⅞ L	T R—½ L	D R—T
	Tank top center and margin plates	D R—T	D R—T	D R—T

168	Depth.	11	12	14
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—¾ L	T R—¾ L
	Center vertical keelson	T R—T	T R—¾ L	T R—¾ L
	Side keelsons	T R—⅞ L	T R—½ L	T R—½ L
	Tank top center and margin plates	T R—½ L	D R—T	D R—T

192	Depth.	12	14	16
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—½ L	D R—T	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—¾ L	T R—¾ L
	Center vertical keelson	T R—T	T R—¾ L	T R—¾ L
	Side keelsons	T R—⅞ L	T R—½ L	T R—½ L
	Tank top center and margin plates	T R—½ L	T R—½ L	D R—T

216	Depth.	14	16	18
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—⅞ L	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—¾ L
	Center vertical keelson	T R—T	T R—⅞ L	T R—⅞ L
	Side keelsons	T R—⅞ L	T R—½ L	T R—½ L
	Tank top center and margin plates	T R—½ L	T R—½ L	D R—T

240	Depth.	15	17	20
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—⅞ L	T R—½ L
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—¾ L
	Center vertical keelson	T R—T	T R—T	T R—¾ L
	Side keelsons	T R—⅞ L	T R—⅞ L	T R—½ L
	Tank top center and margin plates	T R—¾ L	T R—½ L	T R—½ L

264	Depth.	17	19	22
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—¾ L	T R—½ L
	Bilge plating	T R—T	T R—T	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—T
	Center vertical keelson	T R—T	T R—T	T R—¾ L
	Side keelsons	T R—¾ L	T R—¾ L	T R—½ L
	Tank top center and margin plates	T R—¾ L	T R—½ L	T R—½ L

288	Depth.	18	21	24
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—¾ L	T R—½ L
	Bilge plating	T R—T	T R—T	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—T
	Center vertical keelson	T R—T	T R—T	T R—T
	Side keelsons	T R—¾ L	T R—¾ L	T R—½ L
	Tank top center and margin plates	T R—¾ L	T R—½ L	T R—½ L

LENGTH OF VESSELS.

312	Depth.	20	23	26
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—¾ L	T R—½ L
	Bilge plating	Quad—½ L	T R—T	T R—T
	Sheer strake; stringers and ties	Quad—½ L	T R—T	T R—T
	Center vertical keelson	Quad—½ L	T R—T	T R—T
	Side keelsons	T R—T	T R—¾ L	T R—¾ L
	Tank top center and margin plates	T R—¾ L	T R—¾ L	T R—½ L

336	Depth.	21	25	28
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—¾ L
	Bilge plating	Quad—½ L	T R—T	T R—T
	Sheer strake; stringers and ties	Quad—½ L	T R—T	T R—T
	Center vertical keelson	Quad—½ L	T R—T	T R—¾ L
	Side keelsons	T R—T	T R—¾ L	T R—¾ L
	Tank top center and margin plates	T R—¾ L	T R—¾ L	T R—½ L

360	Depth.	23	26	30
	Garboards	Quad—½ L	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—¾ L
	Bilge plating	Quad—½ L	Quad—½ L	T R—T
	Sheer strake; stringers and ties	Quad—½ L	Quad—½ L	T R—T
	Center vertical keelson	Quad—½ L	T R—T	T R—T
	Side keelsons	T R—T	T R—T	T R—¾ L
	Tank top center and margin plates	T R—T	T R—¾ L	T R—½ L

384	Depth.	24	28	32
	Garboards	Quad—½ L	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—½ L	Quad—½ L	T R—T
	Sheer strake; stringers and ties	Quad—½ L	Quad—½ L	T R—T
	Center vertical keelson	Quad—½ L	Quad—½ L	T R—T
	Side keelsons	Quad—½ L	T R—T	T R—T
	Tank top center and margin plates	T R—T	T R—¾ L	T R—¾ L

408	Depth	26	31	34
	Garboards	Quad—½ L	Quad—¾ L	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—½ L	Quad—½ L	T R—T
	Sheer strake; stringers and ties	Quad—½ L	Quad—½ L	T R—T
	Center vertical keelson	Quad—½ L	Quad—½ L	T R—T
	Side keelsons	Quad—½ L	Quad—½ L	T R—T
	Tank top center and margin plates	T R—T	T R—T	T R—T

432	Depth.	27	32	36
	Garboards	Quad—¾ L	Quad—½ L	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—¾ L	Quad—½ L	Quad—½ L
	Sheer strake; stringers and ties	Quad—¾ L	Quad—½ L	Quad—½ L
	Center vertical keelson	Quad—½ L	Quad—½ L	T R—T
	Side keelsons	Quad—½ L	Quad—½ L	T R—T
	Tank top center and margin plates	T R—T	T R—T	T R—T

456	Depth.	28	32	36
	Garboards	Quad—¾ L	Quad—½ L	Quad—½ L
	Bottom and side plating	Quad—½ L	T R—T	T R—T
	Bilge plating	Quad—¾ L	Quad—¾ L	Quad—½ L
	Sheer strake; stringers and ties	Quad—¾ L	Quad—¾ L	Quad—½ L
	Center vertical keelson	Quad—½ L	Quad—½ L	T R—T
	Side keelsons	Quad—½ L	Quad—½ L	T R—T
	Tank top center and margin plates	T R—T	T R—T	T R—T

480	Depth.	30	33	36
	Garboards	Quad—¾ L	Quad—½ L	Quad—½ L
	Bottom and side plating	Quad—½ L	T R—T	T R—T
	Bilge plating	Quad—T	Quad—¾ L	Quad—¾ L
	Sheer strake; stringers and ties	Quad—T	Quad—¾ L	Quad—¾ L
	Center vertical keelson	Quad—¾ L	Quad—½ L	Quad—½ L
	Side keelsons	Quad—¾ L	Quad—½ L	Quad—½ L
	Tank top center and margin plates	T R—T	T R—T	T R—T

504	Depth.	30	33	36
	Garboards	Quad—T	Quad—¾ L	Quad—¾ L
	Bottom and side plating	Quad—⅞ L	Quad—⅞ L	T R—T
	Bilge plating	Quad—T	Quad—T	Quad—¾ L
	Sheer strake; stringers and ties	Quad—T	Quad—T	Quad—¾ L
	Center vertical keelson	Quad—T	Quad—¾ L	Quad—½ L
	Side keelsons	Quad—¾ L	Quad—½ L	Quad—½ L
	Tank top center and margin plates	T R—T	T R—T	T R—T

1. For flat plate keels, see Table 8.
D R — T = double riveted throughout.
T R — T = treble " "
Quad — T = quadruple " "
T R — ½ L = treble " for ½ length amidships.
T R — ¾ L = " " " ¾ " "
Quad — ½ L = quadruple " " " ½ " "
Quad — ¾ L = " " " ¾ " "

7. The entrance to the shaft tunnel is to be from the main deck, at both ends of said tunnel.
8. Electric lights must be fitted throughout on the double-wire system.

38. Keels and Center-Line Keelsons.

1. KEELS.

(*a*) The flat plate type of keel should be adopted, said keel plates being 20 per cent. heavier than in ordinary

vessels. When a double plate keel is required, a single plate keel may be worked if the tabulated thickness is increased by 75 per cent.

(*b*) The width of said keel plates should be 1 1-2 times their width in ordinary vessels so as to provide for a secure attachment of the frames to said plates.

(*c*) It is recommended that said keel butts be overlapped. When straps are used they must be worked double.

2. CENTER-LINE KEELSONS.

The center-line keelson is to form the bottom strake of the center-line longitudinal bulkhead, and should be worked continuously all fore-and-aft. Said keelson is to be deep enough so as to have its lap with the plating above it clear of the floor brackets to said bulkhead. The lower keelson angles to a flat plate keel may be cut at an athwartship bulkhead, but such is not recommended. Said keelson should maintain its midship weight for 2-3 length amidships.

39. Frames.

1. The frames may be cut 9 inches short of the center-line keelson so as to allow a free flow for the oil to the pumps.

2. In two-deck vessels, when cut at the second-deck stringer, the frames between decks are to be secured to said stringer plate by large brackets, equal to the thickness of the frame flange to which they are attached, with at least a six-rivet connection to the frames and to the deck-angle clips.

3. Frame bars are to be worked single at all athwartship tank bulkheads.

40. Floor Plates.

1. Floor plates should be secured to the center-line keelson or bulkhead by angle clips of at least 3 inches by 3 inches, and by a bracket plate of the same weight as the floors. Said brackets are to be on each side 1 1-2 times the depth of midship floors and overlap onto the floors. If said brackets have a flanged diagonal edge, or a clip in lieu of same, they may be 2 1-2 pounds less in weight than otherwise.

2. When the frame numerical is 70 and above the angle clips securing the floors and their bracket plates to the center-line keelson or bulkhead must be of such a size as to allow of double zigzag riveting in both flanges.

3. The floor plates are to be worked at the bilge as in ordinary vessels; or bracket plates may be fitted at said point. When the frame numerical is below 50 said brackets need be fitted to alternate frames only.

4. Limber holes are to be cut in all floors as in ordinary vessels.

41. Reverse Frames.

1. When compound frames are adopted all the reverse frames must extend at least to the "crown deck."

2. With bulb angle frames reverse clips must be fitted to the frames in way of all side stringers; having a three-rivet connection to said frames, but a two-rivet connection to the stringer angle bar when the stringer plates are not supported by knee brackets at alternate frames.

42. Floor Side Keelsons.

1. When said keelson angles are cut at a bulkhead they are to be securely bracketed to said bulkhead; the diagonal edge of the brackets being flanged when the keelson angles are 6 by 4 inches or above.

TABLE 10.—TYPE OF FLOOR KEELSONS.

Molded Beam. Feet.	28	30	34	36	38	40 and 41	42 and 43	44
Number of keelsons.....	2	2	2	2	2	2	2	2
Type of first keelson.....	D A+I P	D A+I P	D A+I P	D A+I P	D A+I P	D A+I P+B A	D A+I P+K P T A	D A+I P+K P T A
" " second keelson.....	D A	D A	D A	D A+B A	D A+I P+B A	D A+I P+B A	D A+I P+B A	D A+I P+K P T A

D A = double angles: I P = intercostal plate: B A = bulb angle: K P T A = keelson plate with double top angles.
Keelson plate to be in depth twice the broader flange of the keelson angles.
Bulb angles to be of the size required for second deck beams.

43. Web Frames.

1. The web-frame plates are to equal the thickness of the standing flange of the frame bar to which they are attached, and be in width not less than four times the depth of said flange.

TABLE 11.—ARRANGEMENT OF WEB FRAMES AND SIDE STRINGERS.

Depth in Feet to the Upper Deck.	Web Frames. Width.	Weight.	Spacing.	Number of Side Stringers and Bulkhead Horizontal Stiffeners.	Type of Vessel.
	Inches.	Lbs.	Frames.		
14	16	12⅛	6	2	One-deck vessels.
16	16	13¾	6	2	" " "
18	18	15	6	3	" " "
20	18	17⅛	6	2	" " " with hold beams.
22	20	17½	6	2	" " " " " "
24	20	17⅞	6	2	Two " "
26	22	17⅞	5	3	" " "
28	22	18¾	5	3	" " "
30	22	18¾	5	2	" " " with hold beams.
32	24	20	5	2	Three " "

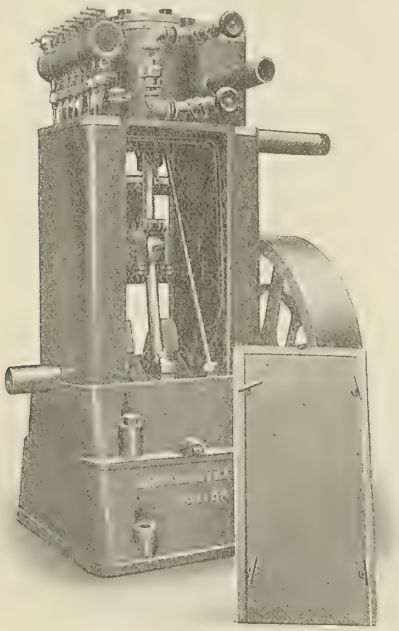
When strong hold beams are required they must be fitted in way of each web frame, and the side stringer in way thereof is to be increased to the width required for lower deck stringers.

ENGINEERING SPECIALTIES.

The Boston Steam Engine.

Carefully designed to fulfill any work to which it may be put, this engine combines the neatness and freedom from dirt of the cast-iron-frame engine with the lightness and accessibility of the open type. All of the working parts are inclosed in a double casing of Russia iron. The inside casing takes all the splash of the oil, leaving the outside casing always clean. This casing is made in four parts, the front and back being fastened with catches which allow of instant removal for any ordinary inspection, while the end pieces can be taken off by the removal of a few machine screws if a thorough overhauling should be necessary.

The pistons are steel castings and the crossheads are steel or phosphor-bronze. The connecting rods are steel forgings with composition boxes lined with white metal. The valve gear, with exception of eccentric and governor weight, is of steel or composition. The crank shaft is of forged steel carefully balanced with counterweights of cast iron. The frame is of rolled steel with diagonal bracing to prevent vibration. The governor is of



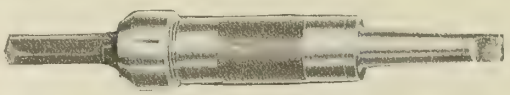
the inertia type, thus insuring the closest regulation. The double ported piston valves are placed as close to the cylinder as possible, thus cutting down the clearance spaces and steam consumption to the smallest amount. The wearing surfaces are of ample proportions to insure cool running at the highest speeds. Lubrication is secured in the smaller sizes by multiple-feed oil tanks and gravity feed, but in the larger sizes oil pumps for forced lubrication are fitted.

For electric generating sets these engines are especially suitable on account of their high speed and cleanliness. The entire inclosing of the working parts permits the engine to be almost flooded with oil without any finding its way into the dynamo. For these sets an extended base is furnished, which supports both engine and dynamo, thus making the whole plant self-contained. For fans or centrifugal pumps, especially for use on shipboard, these engines should commend themselves to all users, not only on account of their lightness, compactness and accessibility, but because dust and ashes from the fireroom will always be excluded from the working parts, which may be covered with oil without making a dirty engine room.

The engines are made by the Boston Steam Engine Company in eight sizes, ranging from 1¾ to 32 horsepower, and running at from 1,000 to 400 revolutions per minute, respectively.

Rich Drills and Chucks.

The introduction of high-grade tool steels, known as high-speed or air-hardening steels, has revolutionized machine-shop practice. Cutting speeds have been greatly increased, and the capacities of machine tools have been more than doubled. Most machine-shop drilling, however, has been done with twist drills, so manufactured that when made of high-grade tool steel they are very expensive; and the shape of the drill, involving as it does a shank, necessitates the waste of much expensive material in a part of the drill which is practically useless so far as cutting is concerned, while the danger of breaking and thereby spoiling an expensive tool discourages its wide use. The Rich flat drill is a device designed to fill the demand for a cheap drill capable of operating at high speeds and heavy feeds in hard and tough materials. It is made of a rolled bar of very carefully selected high-speed tool steel of the highest quality. Suitable lengths are cut from the bar and very carefully tempered throughout their entire lengths, and ground true to form.

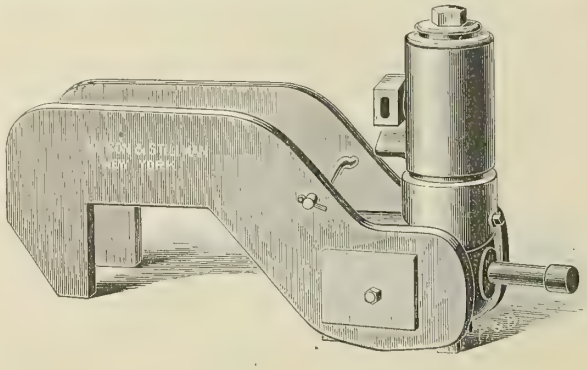


The chuck has been designed as a drill-press attachment for holding the flat drill dead true and absolutely firm by adjustable jaws, which are set up by the thrust block within the barrel. The position of this thrust block is regulated by the external adjusting nut, by which compensation for the wearing of the point by grinding may be made. These drills and chucks are manufactured by the George R. Rich Manufacturing Company, Buchanan, Mich.

Some of the advantages claimed for these drills and chucks are that they may be used at heavy feeds and high speeds; will drill the hardest kind of material; retain a sharp cutting edge much longer than the ordinary drill, and when they must be sharpened the grinding is easy; and the drills are tempered throughout, and can be used to within two inches of the end. At the New York Navy Yard ten holes were drilled in the armor-plate turrets on the battleship *Connecticut* with a 1¼-inch flat drill, while eight twist drills were used without finishing one hole. In an endurance test at one of the Carnegie steel rail mills, a set of these flat drills each drilled 1,600 holes one inch in diameter in 80-pound rails without being reground.

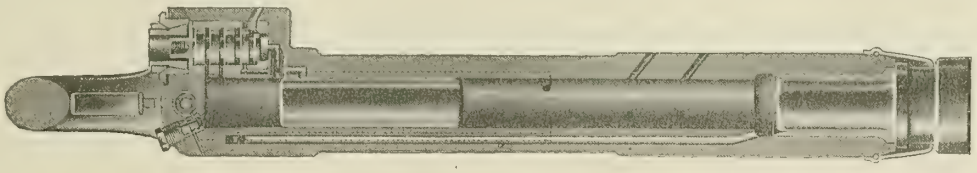
A Coupling-Bolt Forcer.

For the purpose of forcing in or out the coupling bolts on flanges of steamship shafts, the Watson-Stillman Company, of New York, has placed upon the market a number of instruments of varying design and capacities to suit the special requirements of each case. There are three designs, the smallest of which has a frame in one piece and acts much like a hydraulic punch, except that there is no return action to the ram. It can exert a force equivalent to fifteen tons. Another type has a movable cylinder with stationary ram, and has been used to some extent



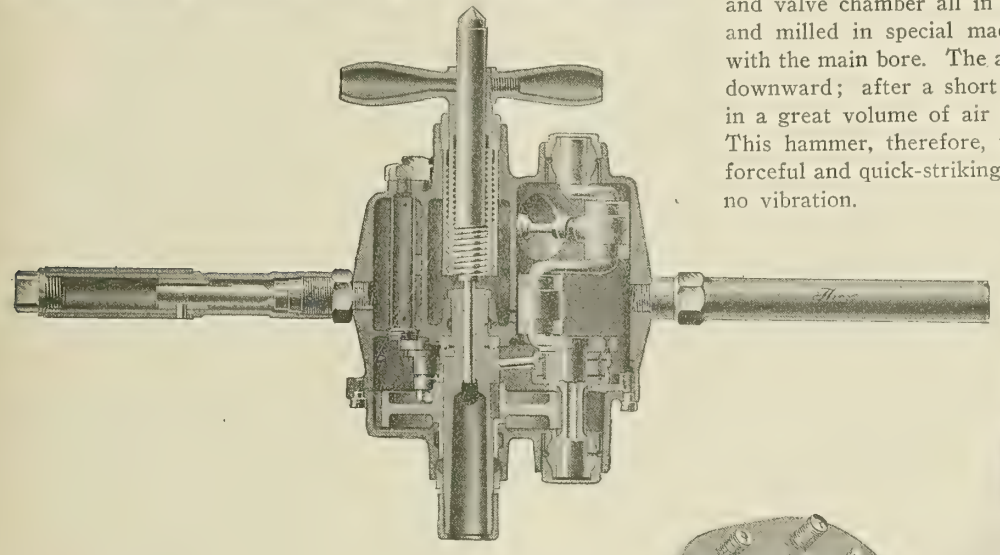
for the purpose above specified on ships of the United States Navy. It can be used in close proximity to a bulkhead. The force applied varies from fifteen to forty tons, according to the dimensions selected.

The third type, which is the one we illustrate, is the same in action as the others, but is larger and more powerful. The ram is movable and has a stroke of three inches. The sizes vary from 25 to 40 tons in power, and in some of the designs an arrangement is made whereby the ram can be drawn back into position after having forced out the bolt.



Thor Pneumatic Tools.

We illustrate herewith a sectional view of the non-reversible drill made by the Independent Pneumatic Tool Company, of Chicago, which differs in a number of ways from other drills on the market, being of the reciprocating piston type, and having four single-acting cylinders placed in the body of the machine.



The admission of air to the cylinders is controlled by means of Corliss valves placed immediately adjacent to the cylinder. The air is magazined and controlled within three-eighths of an inch or less of the cylinders, and when released acts practically instantaneously upon the pistons. The valves are operated from one double eccentric, which is provided with an individual bearing independent of the crank shaft or any other working part of the motor, and is driven from the crank shaft by means of a spur gear. The bearings of the crank shaft are placed close to the crank, which makes a saving in the total length of the motor equal to the length of the eccentric. One of the new features is the telescopic feed. The feed rod consists of an externally-threaded rod which works through an internally-threaded sleeve to the extreme limit, and then the sleeve also works out of the motor an equal distance, thus giving a feed practically double that which could be obtained with an ordinary single feed rod. The reversible drills have the same general features, with the addition of a device for admitting air to the cylinders so as to cause the drills to rotate in the opposite direction, which is desirable in reaming, tapping, rolling flues and wood boring. This is done by sending the air through the exhaust port into the valve chamber and thence into the cylinders, instead of by the usual route. This result is accomplished by means of a simple two-way valve which is placed in the admission chamber at the inner edge of the inlet pipe.

The Thor hammers are of two general types, the duplex valve chipping and calking hammer, and the one-piece auxiliary valve long-stroke riveting hammer. The main novelty and greatest advantage of the latter lies in the construction of handle, barrel and valve chamber all in one solid piece of steel forging, bored and milled in special machinery. The main valve lies parallel with the main bore. The auxiliary valve lightly starts the plunger downward; after a short travel the main valve opens and lets in a great volume of air direct and pretty close to the plunger. This hammer, therefore, from a gentle start gets an extremely forceful and quick-striking blow and quick return, with practically no vibration.

A Rotary Circulating Pump.

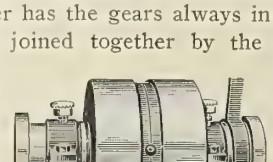
A reliable circulating pump is one of the essential features of all water-jacketed gas or gasoline engines and the more simple, compact and durable it is, the less liability is there of its getting out of order and impairing the efficiency of the engine. To meet this demand the Brown & Sharpe Manufacturing Company, Providence, R. I., has recently placed upon the market a bronze pump that is especially well adapted to this purpose.

The pump is simple in construction, the principal mechanism being a pair of gears that run together in a tight case, there being no valves to leak or get out of order. Either side of the pump can be used for suction, thus allowing it to be run in either direction. The driving shaft is $\frac{9}{16}$ of an inch in diameter,

extends 1⅞ inches beyond the supporting bracket, and has a flat for set-screw. A suitable stuffing box is provided for the outer bearing of the shaft. The supporting bracket has four holes $\frac{5}{16}$ of an inch in diameter. A sprocket wheel and chain are usually employed for operating the pump, which is made in two sizes, weighing 7 and 20 pounds respectively, and delivering from 1 to 8 and from 8 to 40 quarts per minute against heads up to 20 feet, the amount being dependent upon number of revolutions (100 to 500).

A Reversing Clutch for Marine Engines.

A clutch which can be used in connection with any marine engine and propeller has the gears always in mesh, with the two ends of the shaft joined together by the friction sleeves, so



that when the engine is going ahead the propeller is operated by the after cone, and there is no relative motion in the clutch gears. For reversing, the other cone is thrown into action, and is held in position by the thrust of the propeller, thus obviating undue friction on the shaft and the yoke of the lever. In this position the gears operate in the usual manner to give the propeller rotation in a direction the reverse of the preceding. The clutch is fitted with three sets of thrust ball bearings, with a minimum amount of friction. It is placed upon the market by the Holliday Manufacturing and Engineering Company, of Chicago.

TECHNICAL PUBLICATIONS.

Houseboats and Houseboating. Edited by Albert Bradlee Hunt. Size 9½ by 12 inches. Pages 216 + xv. Illustrations 198. New York: Forest and Stream Publishing Company, 1905. Price $3.00.

This is by all odds the most complete and valuable book on the subject of houseboats which has come to our attention. It is devoted mainly to houseboating as it exists in the United States, but one considerable chapter is taken up with houseboating in England, where the sport, if such it may be called, has attained probably a higher degree of perfection, and certainly a greater degree of popularity than is the case in the United States. The subject is taken up from all points of view, structural, decorative and that of mobility. Boats have been shown both by photographs and by accommodation plans and profiles which are propelled in the several cases by sails, by steam engines and by internal combustion motors, as well as barges having no propulsive power of their own, and depending for their mobility upon outside means of traction. A large number of boats of various classes, sizes and elaborateness are described in detail, with both interior and exterior views in great profusion, and the large variety of examples given is what makes the work so extremely valuable to anyone interested in the subject. While it may be said that the lines of a houseboat as such are of purely secondary consideration, because of the very low speed at which these boats always move, yet a number of cases will be found here where the lines are given. The last chapter, which consists of fifteen pages, is a description of the inside route from New York to Florida, giving distances in miles, and the general conditions to be met en route, together with lists of charts and a great variety of information of importance to anyone navigating over the course.

The book should have a ready acceptance at the hands of every one interested in the subject from the point of view of ownership or prospective ownership of a houseboat, while its value to those concerned in the design and construction of these craft must be very great, indeed.

Bureau Veritas: Rules for the Fitting-up of Motor Boats and Motors. Size 5¼ by 8¼. Pages 19. Published by Bureau Veritas, 8 Place de la Bourse, Paris, 1905.

This little pamphlet covers rules for the general use of constructors of motor boats and the machinery therefor, giving in considerable detail the requirements to be met in connection with the various devices used, and with regard to the installation of the motor into various types of boats.

Pocket Book of Mechanical Engineering. By Charles M. Sames, B. Sc. Size 4 by 6¾ inches. Pages 168. Bound in flexible leather. Published by the author, Jersey City, N. J., 1905. Price $1.50.

This is a condensed mechanical engineers' pocketbook, covering the same general scope of practice as with the larger and more elaborate books, but going far less into detail in that it gives only the most important and most generally used tables, data, formulas, etc. It has been compiled from information found in standard treatises and reference books, technical periodicals and various other sources, and is a first edition.

Gas, Gasoline and Oil Engines. By Gardner D. Hiscox, M. E., Size 6 by 9 inches. Pages 442; figures 351. New York: The Norman W. Henley Publishing Company, 1906. Price $2.50 net.

This is a very comprehensive and thoroughly modern treatise, taking up the subject from the American point of view. It goes fully into the construction, installation, operation and maintenance of engines of the types included under the heading, covering internal combustion motors for stationary, marine and automobile use. The illustrations are very complete and well chosen, giving details of construction, as well as diagrams and illustrations of every sort of device which is used by various makers for the operation of the motors.

Tabulated sizes of parts are given and considerable valuable information on testing plants for economy and for the power produced by the engines. To add to its value as a reference book, there is given a list of the leading gas and oil engine manufacturers in the United States and Canada; together with a 22-page list of United States patents on these engines, covering the period from 1875 to September 1, 1905, inclusive.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 311.—Please advise me what the requirements are for examination for license to run a steam plant in a pleasure launch of about 10 horsepower. A. L. H.

A.—The term "horsepower" does not enter into the question of granting licenses to engineers, special grades of license being based upon tonnage. A person may obtain a special license as an engineer of pleasure steamers of ten tons and under without regard to the horsepower of the engine, by simply satisfying the local inspectors that he is qualified for the said special license. There are no specified legal requirements for this class of license, the question of qualifications being a matter that is wholly within the discretion and judgment of the local inspectors to whom the person applies for license. If the steamer is more than ten tons, no matter whether the engine be a 2 horsepower or 100 horsepower, then the engineer must be licensed in accordance with Section 24, Rule V, General Rules and Regulations of the Steamboat Inspection Service, Department of Commerce and Labor.

Q. 312.—Do you think the present rule of rating horsepower is correct? For instance, I have a 3-cylinder, 4-cycle motor, 3⅝-inch bore, 4½ stroke, rated by the manufacturer as 10 horsepower at 900 revolutions. This motor would turn a 2-blade, 16-inch-diameter, 21-inch-pitch propeller 875 revolutions per minute. I tried a pair of blades 20 inches diameter 24-inch pitch and turned them 650 revolutions per minute, making a boat speed of 9 miles an hour, this speed rating the motor about 7.5 horsepower. Boat made about the same time as 16-inch 21-inch pitch, or 10 horsepower. I then tried a pair of blades 18 inches diameter, 27 inches pitch, and turned

them 590 per minute, or rating motor not 7 horsepower, and made 8 knots. It seems to me as though any motor with a certain bore, length of stroke and compression will give only a certain amount of power. This motor is in a hull 24 feet 10 inches long, 4 feet 6 inches beam at load waterline, 12 inches draft, widest beam three-fifths aft of bow. W. E. G.

A.—The fact that your motor in the second case turned the propeller 650 revolutions per minute only, in place of 875 in the first case, is in itself no definite indication that it was operating at only 7.5 horsepower in place of 10, because a great deal would depend upon the character of the indicator cards under the two conditions. You state that in the second case the speed of the boat was about the same as the first. This would have been the case had the power been the same in each case; or it would be the case if the power in the second instance were less than in the first, but the general efficiency of the propeller in itself and as adapted to the hull correspondingly greater. The third case seems to bear out this general line of reasoning.

Q. 313.—Would like you to give me a formula by which to calculate diameter, pitch and blade area for propellers for a twin-screw steamer of very blunt lines, length on waterline 166 feet, beam 40 feet; draft, aft 11 feet, forward 9 feet, when light, and average 16½ feet when loaded; indicated horsepower 800; revolutions 125 per minute. I find a number of formulas in Seaton, Kent, etc., but none applicable to twin screws for blunt boats. C. G. B.

A.—The question of the design of a propeller for a specific case of the unusual characteristics of the present one is not at all clearly defined, and a great deal of the design must necessarily depend upon experience with cases more or less similar to the one in hand. A formula found on page 263 of Durand's "Resistance and Propulsion of Ships" is:

$$(d')^2 = \frac{U}{(p'N')^3 \times (i\,k\,l\,m)}$$

where d' is the diameter of the propeller, expressed for convenience in units each of which is 10 feet, p' is the pitch of the propeller in the same units, N' is the number of tens of revolutions; i, k, l and m are coefficients depending respectively upon the form of blade, the slip of the propeller, the pitch ratio and the reaction between the propeller and the hull; U is the actual power delivered by the propeller upon the water, and in the present case would be probably not more than from 45 to 50 percent of the indicated horsepower of the engines. It should be noted that this latter term refers to the power on one shaft and not to the total power. Assuming a propulsive coefficient of 50 percent, the horsepower delivered by each propeller would be 200. If we, moreover, assume that the ship has a displacement of 2,500 tons, then with an admiralty coefficient of performance of 140, the speed would be 8.5 knots. Assuming from the bluntness of the lines that the propellers will work at a slip of about 30 percent, and taking a pitch ratio of 1.1, we find from tables on pages 253, 264 and 265 of the work above quoted values for i, k, l and m which are respectively 1.2, 0.214, 0.739 and 1.07; while the factor $(p'N')^3$ becomes 1.977 from the fact that $pN = \frac{8.5 \times 101.3}{1 - 0.30} = 1{,}255$.

Following these values through the formula first given, we find that $(d')^2 = 0.499$, whence $d = 7$ feet 1 inch, and $p = 7$ feet 9 inches.

It is more than likely that these figures would have to be very materially modified from experience with the wheel itself. They are not intended to give a solution of the problem as stated, but merely to show the manner by which such a solution may be obtained. Without more definite knowledge regarding the various characteristics of the hull, it would be out of the question to attempt any accurate quantitative solution.

Q. 314.—I wish to ask a question concerning the proper size of piston rod, at the smallest point, for a given diameter of cylinder, length of stroke, pressure and revolutions. Have looked in several books for a good and safe formula, but as yet have not seen one. Can you suggest a rule which is both practical and safe? J. M. F.

A.—The diameter of a piston rod would depend entirely upon the diameter of cylinder, length of stroke and pressure of steam, as the number of revolutions per minute would have no effect upon its determination. Formulas for taking care of such a problem are to be found in all working manuals of marine engineering. The one we give below is taken from page 163 of Seaton's "Manual of Marine Engineering." The piston rod may be assumed as fixed at the end at which it is joined to the piston, and loose at the crosshead end, because the crosshead would offer little resistance to bending. The formula is as follows:

$$P = \frac{2fS}{2 + 5a\frac{l^2}{d^2}},$$

where P = the load on the piston in pounds; l = the length of the piston rod; d, its diameter; a, a coefficient given as 1/3,000; S, the area of the piston rod section, and f the safe fiber stress to be allowed on the material, which may be stated to be 5,000 pounds per square inch. If we substitute for P its equivalent $p \times \frac{\pi D^2}{4}$, where p is the pressure per square inch on the piston when that pressure is a maximum, and D is the diameter of the piston; and further substitute the value above given for f, our formula becomes:

$$pD^2 = \frac{10{,}000d^2}{2 + \frac{l^2}{600d^2}}.$$

This is a formula involving biquadratics, as will be seen upon the working out of a specific case.

Let us take a cylinder with diameter 20 inches, length of piston rod 30 inches, and steam pressure 150 pounds per square inch: then the formula becomes:

$$60{,}000 = \frac{10{,}000d^2}{2 + \frac{900}{600d^2}}.$$

This formula readily reduces to $12 + \frac{9}{d^2} = d^2$, and the solution gives the value of d as about 3⅝ inches. With $f = 6{,}000$, d becomes 3¼ inches.

Q. 320.—Can you give me a rule for estimating the power necessary to drive a launch at a given speed?—say for boats from 15 to 75 feet length? J. P. L.

A.—The formula used for estimating the power necessary to drive a launch at a given speed is:

$$H = \frac{D^{\frac{2}{3}} \times V^3}{K},$$

where H is horsepower, D = displacement of the launch in tons of 2,240 pounds each, V = speed of the launch in knots, and K is a coefficient the value of which depends partly upon the size of the launch, partly upon the lines of the launch and the adaptation of the propeller to those lines. For a launch of easy lines, of considerable size and low speed, this constant may reach 225. For a high-speed launch of relatively small size it would probably be not greater than 100. Experience and practice are necessary for the determination of the coefficient to be used in each specific case, but it may be said that for cases where the form is average or easy and the speed is not excessive, the figure would be found usually from 150 to 180.

Q. 322.—What formula is used to determine the thickness of a boiler-shell plate for a given steam pressure? Please give formula to determine the pitch of rivets in seams, and if you know of any book that gives such formula, please mention. G. H.

A.—The formula for determining the thickness of boiler plate is:

$$t = \frac{pD}{2s}.$$

This comes from a consideration of the fact that the steam pressure within the boiler tending to disrupt it is $p \times D \times L$, where p is the pressure in pounds per square inch, D is the diameter of the boiler in inches, and L the length in inches; on the other hand, the force tending to hold the shell together is $s \times 2t \times L$, where s is the safe fiber stress of the material in pounds per square inch, t is the thickness of the material in inches, and L, as before, the length of the boiler in inches.

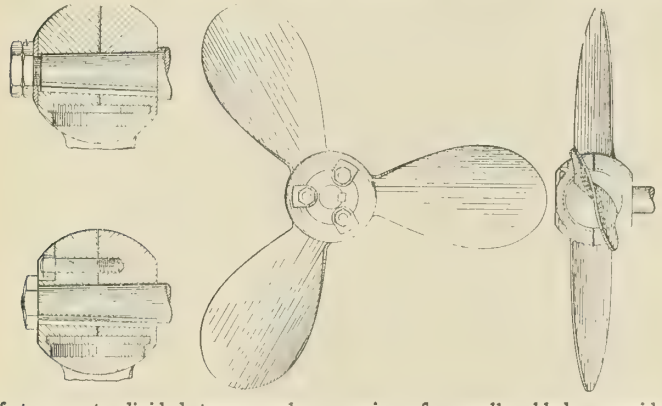
The diameter of rivets used comes from a consideration of the relative strength of the rivets against shearing off to the tensile strength of the part of the plate not cut away by the rivet holes. General practice makes the diameter of the rivet about 1.8 times the thickness of the plate; the pitch of the rivet for single riveting about 2½ times the diameter of the rivet; and for double riveting about 3½ times the diameter.

This information is contained in all works of marine engineering, particularly those concerned with design.

SELECTED MARINE PATENTS.

800,918. ADJUSTABLE PROPELLER. FRANKLIN G. HOBART, BELOIT, WIS., ASSIGNOR TO FAIRBANKS, MORSE & CO., CHICAGO, ILL.

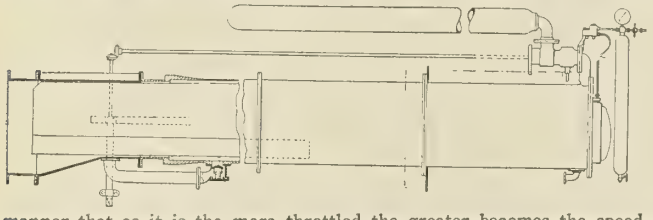
Claim.—1. An adjustable propeller comprising a clamping hub composed



of two parts divided transversely, a series of propeller blades provided with rotatable flanged shanks engaging undercut recesses in said hub, and means for tightening the two parts of the hub together to clamp said shanks in any desired position. Two claims.

801,792. BROADSIDE UNDER-WATER TORPEDO-LAUNCHING APPARATUS. ALBERT E. JONES, WEYMOUTH, ENGLAND, ASSIGNOR TO WHITEHEAD & CO., FIUME, AUSTRIA.

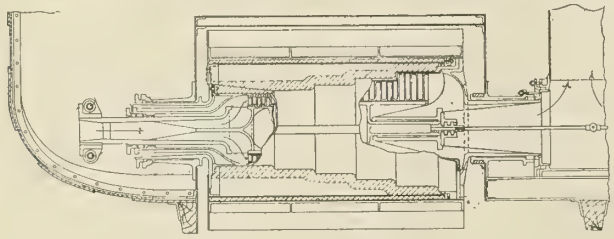
Abstract.—According to the present invention the initial pressure of the fluid used for pushing out the torpedo-casing and which is sufficient to impart to the torpedo a predetermined speed in the release position is left unaltered; but the admission of the fluid under pressure to the tube in rear of the piston operating the torpedo is automatically governed in such



a manner that as it is the more throttled the greater becomes the speed of the torpedo-casing. Thus the torpedo-casing and the torpedo will arrive in the release position of the latter always with one and the same speed regardless of the speed of the ship and any other circumstances that might affect the movement of the torpedo-casing. Immediately after the torpedo has been released the backward or inboard movement of the torpedo-casing is effected by fluid under pressure in a positive manner by means of a mechanism to which fluid under pressure is admitted automatically when the torpedo-casing has reached the torpedo-releasing position. Five claims.

802,648. MEANS FOR PROPELLING SHIPS. JOHANN C. KUNST, BRAKE, GERMANY.

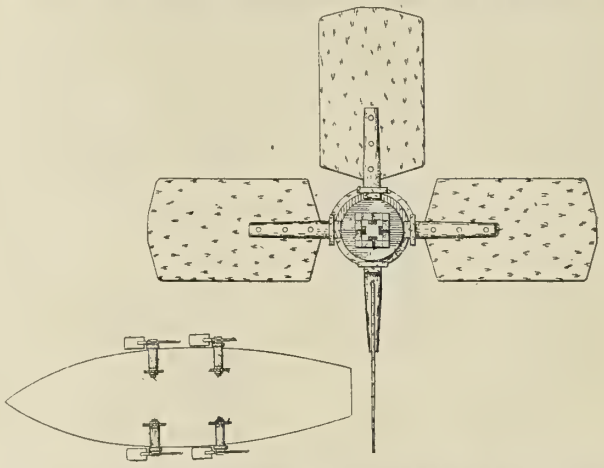
Abstract.—The invention relates to improvements in means for propelling ships; and it substantially consists in arranging within a paddle-wheel a



motor adapted to drive the said wheel. This motor can be a steam-turbine, an electromotor, or any other motor suitable for the purpose. Seven claims.

802,602. PROPELLER FOR BOATS. HERMAN S. SEARLE, ROCHESTER, N. Y.

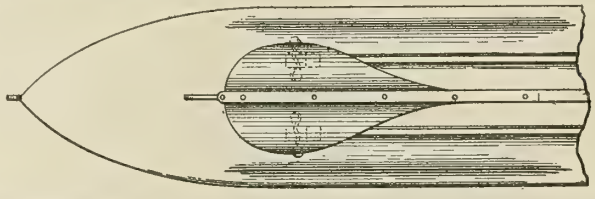
Abstract.—The main object of the invention is to construct the paddles so as to turn in their respective bearings in the shaft and to provide simple



means for turning them automatically at intervals on their axes as they are collectively carried around by the revolving shaft to cause the blades of the paddles to alternately present their faces and their edges to the water. Three claims.

804,497. HULL OF VESSELS. ISAAC E. PALMER, MIDDLETOWN, CONN.

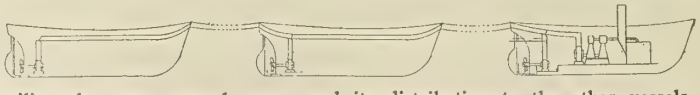
Claim.—2. The combination with the hull of a vessel provided with a channel at the stern portion thereof, of laterally-extended wings forming



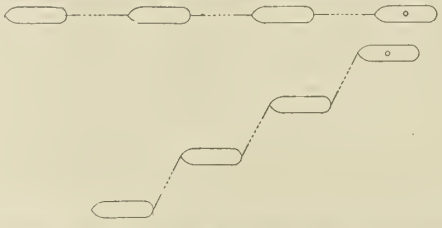
a bottom to said channel and spaced from the wall of the channel to leave an opening for the escape of the water laterally from within the channel, the said wings being constructed to vanish into the keel of the vessel as they extend forward, whereby a free flow of water is maintained through the channel. Four claims.

805,268. MARINE TRANSPORTATION UNIT. WILLIAM T. DONNELLY, BROOKLYN, N. Y.

Abstract. The invention provides for the generation of propelling power, such as electricity, upon one of a fleet or convoy of vessels that are

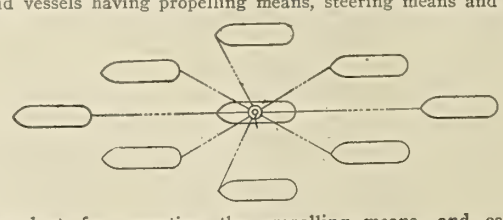


sailing the same general course and its distribution to the other vessels in such a manner that they will be free to make use of it for propulsion and at the same time be free to navigate independently in the vicinity of



the fleet as regards speed, wind, and weather and the avoidance of local obstructions.

Claim.—4. A marine transportation unit comprising a plurality of vessels, one of said vessels having propelling means, steering means and an electric



generating plant for operating the propelling means, and each of the other vessels having independent steering means and independent propelling means operated by electric power supplied from the generating plant of the first-mentioned vessel, substantially as described. Nine claims.

For the photograph and description of the steamer *E. C. Waters,* which appeared at page 520 of our December number, we were indebted to Mr. Elisha Webb, Jr., of Philadelphia.